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INSECT DEVELOPMENT ANALYZED BY EXPERIMENTAL METHODS: A REVIEW

PART I. EMBRYONIC STAGES[1]

BY A. GLENN RICHARDS, JR. AND ALBERT MILLER

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[1] This paper was prepared in the biological laboratories of the University of Rochester and of Cornell University.

I. INTRODUCTION

This is the first of two papers having as their joint purpose an analytical review of the available experimental data on all the phases of insect ontogeny. Development from egg to adult is physiologically a continuous process regardless of the form changes involved. Nevertheless we find it convenient to treat the subject under two arbitrary subheads. The present paper is concerned primarily with development within the egg, while the second will deal with development after eclosion from the egg.[2] Recent reviews in English make it unnecessary to cover in detail such general topics as sex determination, determination of types of individuals, action of genes, and chemical changes during development. However, some of the more recent papers are mentioned when they aid in maintaining a proper perspective.

Although experimental insect embryology is still in a very early stage in comparison with experimental vertebrate embryology, it has reached a point where the literature is sufficiently extensive and the results sufficiently definite to make a résumé in English seem desirable. Such a résumé seems especially valuable because our view-point has changed considerably since Morgan (1927) and Schleip (1929) reviewed certain of the outstanding papers.

Most of the important data on the embryonic stages are of recent date. Historically the first experiments were those of Wheeler (1889) and Megušar (1906) on gravitational effect by the inversion of eggs. The first important experiments were those of Hegner on beetle eggs. In 1908 he studied the effects of puncturing the egg and allowing part of the contents to flow out; in 1909 the effects of centrifugal force, and in 1911 the effects of killing regions of the egg with a hot needle. A lapse of about fifteen years followed, during which the little experimental data came from genetical and cytological investigations. Then, with the work of Reith (1925), Seidel (1926) and Pauli (1927), began the series of experiments that will fill the bulk of this paper. To Seidel and his students we owe most of our knowledge of the vital processes occurring in the insect egg.

[2] Berlese's theory which attempts to harmonize the great diversity found in the ontogeny of the various groups of insects will be discussed in Part II.

For our purposes we shall regard '*determination*' as the process of primary chemo-differentiation that 'sets the course' along which a given region of the egg is to develop, *i.e.*, determines its fate. Determination lays the invisible foundation for morphological differentiation. It may, and probably always does, vary in degree, becoming increasingly more strict as development proceeds, and so may also be expressed as 'a limitation of potencies.' *Differentiation* has been aptly defined by Schnetter (1934a) as "visible distinctive configuration." It is the realization, as visible development, of the capacities of a region acquired by earlier or simultaneous chemo-differentiation.

The degree of determination existing in the egg at a given stage of development is reflected in the ability of the egg to readjust itself toward the production of a normal embryo after a defect is imposed upon it. The more fixed the determination, the less the power of regulation. Insect eggs may accordingly be grouped into (1) *indeterminate*, (2) *incompletely determinate* and (3) *determinate* types. An indeterminate type of egg is one in which the parts of the embryo are not predetermined at the time of fertilization, and hence an egg with great regulative powers under experimental conditions. A determinate type of egg is one in which the parts are wholly predetermined before or during fertilization, and hence an egg with little or no regulative power and given to mosaic formation under experimental conditions. An incompletely determinate type of egg is intermediate between these two. A graded series is found from the highly indeterminate eggs in certain of the lower insect orders through incompletely determinate eggs to the completely determinate eggs of the higher Diptera. This indeterminate-determinate series will be discussed in detail later.

Space will not permit a detailed discussion of the morphological course of insect embryogeny. Good accounts are given in recent entomological text-books, *e.g.*, Imms (1934), Weber (1933) and Snodgrass (1935). Such descriptive notes as seem imperative will be given under the forms as discussed.

II. EXPERIMENTAL MATERIALS AND METHODS

The forms experimented upon include Orthoptera, Odonata, Coleoptera, Diptera and Hymenoptera. Both aquatic and ter-

restrial types have been used; study of the development of the latter is frequently facilitated by immersion in water. Observations on living eggs are possible when they are naturally transparent or translucent and in some cases after removal of the chorion (egg-shell) (*e.g.*, Slifer 1932a, Child & Howland 1933). In experimental studies normal eggs are always used as controls and in some problems 'experimental controls' are also used (*e.g.*, partially *versus* completely constricted eggs). The experimental techniques that have been used may be summarized as follows. [References in italics give methods in detail.]

1. **Cauterization**: (a) Killing a small region or several regions with a hot needle either to produce a minute scar or to eliminate certain areas [Hegner 1911 (Chrysomelid beetles); Reith 1925 (*Musca*, the House Fly), 1931b (*Camponotus*, an ant) and 1935 (*Sitona*, a weevil); *Seidel* 1926, *1929b* (*Platycnemis*, a damsel fly); Strasburger 1934 (*Calliphora*, a blow fly); *Howland & Robertson 1934* (*Drosophila*), Oka 1934 (*Gryllus*, a cricket)]. (b) Light cauterization to produce localized contractions of the yolk system [Seidel 1934 (*Platycnemis*)]. (c) Unilateral heating with a microcauterizer to produce minute splits by unequal expansion of the egg materials [Seidel 1928, 1929b (*Platycnemis*)]. (All workers except Hegner used electrically-heated needles, some with micro-manipulator control.)

2. **Irradiation with ultra-violet light** to (a) kill selected nuclei, (b) kill certain areas of the egg, (c) cause temporary changes in the cytoplasm, (d) produce a minute scar, or (e) observe the effect of *in toto* irradiation of oriented eggs [*a-d Seidel* 1929 ff., *1932* (*Platycnemis*); *c Geigy* 1926 ff., *1931b* (*Drosophila*)].

3. **Puncturing** the egg with a cold needle, either to allow part of the egg contents to flow out, or to injure, divide or alter the germ band [Hegner 1908 (Chrysomelid beetles); *Krause 1934* (*Tachycines*, a camel cricket); Sonnenblick 1934 (*Drosophila*); Howland & Child 1935 (*Drosophila*)].

4. **Producing yolk-fissures** by bending the egg [Seidel 1929a (*Platycnemis*)].

5. **Constricting** the egg (completely or incompletely) at various points with a fine hair [Seidel 1926 ff. (*Platycnemis*);

Pauli 1927 (*Calliphora* and *Musca*); Rostand 1927 (*Calliphora*); Reith 1931b (*Camponotus*); *Schnetter 1934b* (*Apis*, the Honey Bee); Brauer & Taylor 1934 (Bruchid beetle)].

6. **Centrifuging** the egg in various positions [*Hegner 1909* (Chrysomelid beetles); Clément 1917, 1921 (*Bombyx*, the Silk Moth); *Pauli 1927* (*Calliphora* and *Musca*); Reith 1932b (*Camponotus*)]. One might also include here the inversion experiments of Wheeler (1889), Megušar (1906) and Hegner (1909).

7. **Modification of environmental factors** [Slifer 1934 (anisotonic salt solutions on *Melanoplus*, a grasshopper); Bodine *et al.* (temperature, oxygen tensions, cyanide, etc., on *Melanoplus*), and various workers with temperature, humidity, nutrition, general irradiation with various rays (alpha rays (*Hanson & Heys 1933*), mitogenetic rays (*Wolff & Ras 1934*), x-rays (Henshaw 1934, Smith 1935)), etc., on various insects].

8. **Genetic analysis** of 'normal' mosaics, intersexes and gynandromorphs in studies on fertilization, cell-lineage, sex determination and to a lesser extent organ formation [Goldschmidt 1917 ff. (moths, *Lymantria* and *Bombyx*); Sturtevant 1929 and Dobzhansky 1931 (*Drosophila*); Whiting *et al.* 1924 ff. (*Habrobracon*, a wasp)].

In regard to techniques that have been used upon other invertebrates and upon vertebrates it is of interest to note that (1) separation of early blastomeres is of course impossible due to the superficial cleavage, but this aspect is covered by the above methods nos. *2*, *5* and *8*; (2) vital staining for marking egg-regions has been tried unsuccessfully by Seidel (he did not remove the chorion) and no. *2d* above had to be used instead; and (3) tissue culture methods, parabiotic twinning and operative technique in the sense of transplantations have not been successfully accomplished with insect eggs. The tough chorion together with the turgidity and fluidity of the egg contents hinder manipulation.

III. ORIGIN OF POLARITY AND SYMMETRY

Insect eggs vary greatly in form but may be broadly classified as either radially or bilaterally symmetrical. In either case the eggs may be laid in definite or random positions depending on the species. In bilaterally symmetrical eggs the axes of the presumptive embryo may be externally evident.

1. **Hallez's Law of Orientation:** This 'law' is based on the observation that the mature egg within the ovary lies in such a position that all three axes of the presumptive embryo are oriented coincidently with those of the mother. From this it follows that the embryonic axes are determined in the egg before laying. Although this is certainly a general rule it is not yet proven to be universal. In the radially symmetrical egg of the bug *Pyrrhochoris* Seidel (1924) reports that the longitudinal embryonic axis may vary from being coincident with the longitudinal axis of the egg to being transverse to it. Also there are certain insects (*e.g.*, Melanoplus, Slifer 1932a) in which it is reported that the embryo begins to develop in the reverse position with the head towards the micropylar opening at the posterior end of the egg but that the 'normal' position is attained by a later reversal of the embryo during blastokinesis.

Seidel (1929a) reports that frontal doubling, induced by the production of splits in the egg at the beginning of cleavage and resulting in the formation of mirror-image symmetrical twins within the egg, indicates the determination of a dorso-ventral axis (as well as other axes) at this early stage in the development of *Platycnemis*. Mirror images result from the inversion of one of the three axes in the formation of one partner; this presupposes the existence of polarity at least in the inverting plane. Frontal and lateral doubling have also been induced by splits in the germ band of *Tachycines* (Krause 1934).

2. **The position of the micropyle** is determined by the formation of the egg-shell during growth of the oöcyte. It is usually situated at the center of the anterior end of the egg but may be on one side (Weber, 1933, p. 488) or even at the posterior end (Slifer 1932a). If the point of entrance or course of the sperm is concerned in the determination of the embryonic axes then these in turn are more or less fixed by the position of the micropyle and hence influenced by ovarian factors.

3. **Visible bilaterality** is frequently evident in the external structure and form of the mature egg. A corresponding visible internal bilaterality is sometimes shown by the constant position of the "richtungsplasma" (place where the maturation divisions occur) on the dorsal or ventral mid-line of the egg (Schnetter

1934a, Strasburger 1934). Hirschler (1933) has demonstrated by intra-vitam staining that the original radial symmetry of the egg becomes obviously bilateral during deposition of the yolk in the beetle *Cicindela* but he did not study the relation of this symmetry to that of the future germ band; the two may be coincident.

4. **Germ-Tract Determinant** (germ-plasm, germ-line, pole-cells, pole-disc, Polscheibe, Keimbahn): There is frequently an area of distinct appearance at the posterior end of the unfertilized egg. The cleavage nuclei which enter this region are destined to give rise to the definitive germ cells of the embryo. This area frequently contains numerous granules that stain conspicuously. Huettner (1923) shows that they are neither small yolk granules nor mitochondria; presumably they are merely byproducts of the 'germ-plasm.' In any event the area is most probably determined by extra-oval factors and does not act in the determination of the embryonic axes.

5. **Gravity and centrifugal force:** Wheeler (1889) and Hegner (1909) report that the position of the eggs of the Cockroach and Chrysomelid beetles has no effect on development. The single reported exception is the beetle *Hydrophilus* in which Megušar (1906) reports that if the aquatic egg-capsules are inverted development is retarded and the few larvæ which hatch are deformed and soon die (the embryos, however, were in their normal position within the eggs). His results, based on only two capsules of eggs, are inconclusive since he did not consider the modification produced in factors other than gravity, for instance the inversion of air-water relations.

Hegner (1909), Pauli (1927) and Reith (1932b) report that the orientation of embryos produced by centrifuged eggs is unaffected although the visible materials are redistributed and stratified. Centrifugal force has much less effect on eggs within the ovaries (Hegner 1909, Clément 1917, 1921), either due to less effect on growing or mature oöcytes or to a restitution within the oöcyte.

From the above fragmentary notes it is evident that the fundamental processes underlying the determination of polarity and symmetry are still a matter of conjecture. In bilaterally sym-

metrical eggs, at least, both polarity and symmetry must be determined during growth of the oöcyte. The development of polyembryonic eggs (certain parasitic Hymenoptera) might throw some light on this question but the available data can not be analyzed from this view-point. Cappe de Baillon's (1925b) data clearly suggest to us that this early determination of the fundamental axes begins at or near the anterior end and progresses posteriorly (see Section VI).

IV. FERTILIZATION

1. **Activity of the spermatazoa:** Activated sperm have an undulatory movement but it is not known whether this movement functions during penetration of the insect egg or only furnishes motile power to pass through the micropyle. The tail, in all reports we have noted for insects, is carried into the egg. How the sperm move through the interior of the egg after entrance is unknown, but it is of interest to note that Huettner (1927) observes their distribution throughout the egg in abnormally highly polyspermatic eggs of *Drosophila*. Also little is known concerning the reactions of the sperm themselves, but Howland (1932) reports that in *Drosophila* the sperm are highly sensitive to the constitution of the surrounding medium and easily killed.

2. **Monospermy and polyspermy:** In some insects only a single sperm can be found within a fertilized egg (Johannsen 1929) but in most insects several or many sperm enter. Huettner (1924, 1927) reports that supernumerary sperm in *Drosophila* eggs degenerate, only rarely forming mitotic figures. If, however, the degree of polyspermy is too great it may lead to disturbances which prevent further development. These disturbances are usually due to disorganization of the maturation divisions by sperm which enter this region of the egg. Such sperm may form uni-, bi- or multipolar spindles, or even enter normal spindles to form multipolar figures. This condition may or may not become adjusted. In binucleate moth eggs Doncaster (1914) and Goldschmidt & Katsuki (1928) report that each nucleus fuses with a sperm. Genetic evidence shows that the same is true for some binucleate eggs of the wasp *Habrobracon* (Whiting 1934). In no case is there any evidence of a sperm

functioning except after uniting with an egg nucleus, but Huettner (1927) postulates that such is possible and shows that it might conceivably be followed by normal development.

3. **Selective fertilization**: In the true sense this is unknown in insects although it may be simulated in some instances by a partial or complete mortality of one of the expected types. This is presumably the case in sex determination in the Hymenoptera where according to Whiting's theory (1933) biparental progenies should be composed of diploid males and females in equal number. He shows by genetic tests with sex-linked genes and by an inverse correlation of biparental males with total progeny and with egg-hatchability, that the fusion of like gametes is usually lethal—fusion of unlike gametes giving females (normal males are haploid and result from parthenogenesis). A presumed case of selective fertilization in *Drosophila* has been shown due to the necessity of the dominant allelomorph at some time during development even though it be expelled into a polar body (Morgan 1927, p. 58).

4. **Activation of the egg by the sperm**: Ripe insect eggs are usually found to be in the metaphase of the first maturation division and to depend on the entrance of the sperm or the induction of parthenogenesis to continue further (Huettner 1924, Johannsen 1929, and others). In normally parthenogenetic species there is no such cessation at this point, and even in the grasshopper *Melanoplus* which is normally fertilized at this stage King & Slifer (1934) report that there is no visible delay in unfertilized eggs and that the maturation divisions proceed to completion at very nearly the same rate as in fertilized eggs. Accordingly the sperm does not necessarily have an activating function even in eggs which ordinarily undergo fertilization.

5. **Relation of fertilization to cleavage and later development**: It was pointed out above that since the point of entrance and path of the sperm are probably constant in any one species due to the position of the micropyle, it is uncertain whether they bear any relation to the origin of the orientation of the embryo. The only cases in which any part of fertilization is thought to have a bearing on development, other than initiating completion of the maturation divisions, is in incompletely determinate eggs. In this type of egg Reith (1931b, 1935) reports that induction of

the visible zonation of the cortical layer of the ant egg and a similar but not visible determination in the beetle egg start immediately after the beginning of cleavage. How this activation of the activation center is brought about and whether it is caused by the entrance of the sperm, the fusion of the pronuclei or some other factor are unknown.

6. **Fertilization membranes** are seldom mentioned for insects. In the Silk Worm Bataillon & Su (1931a, 1933) report that a strong fertilization membrane is detached from the egg following induced parthenogenesis and in the first brood of two-brooded stocks but not in the second brood or in single-brooded stocks. The significance of this variation is not known.

7. **Centrioles** are present in the eggs of some species, absent from others. Huettner (1933) shows that they are absent from the maturation figures of the egg of *Drosophila* but that they appear at the first cleavage (from the sperm?) and thereafter have a continuous history throughout development. Nachtsheim (1913) believes that in the Honey Bee they are derived from the egg since supernumerary sperm form anastral spindles whereas cleavage cells have conspicuous centrioles. Bataillon & Su (1931b, 1933) report that in the Silk Worm egg they do not appear except from the sperm, and that they are never found in parthenogenetic eggs. Their absence from these parthenogenetic eggs is frequently accompanied by highly abnormal mitotic figures.

8. **Binucleate eggs**: These may and presumably do arise from two different causes: (1) the functioning of two maturation nuclei of a single egg, and (2) the fusion of two eggs. Strangely enough the fusion of two eggs does not result in a giant egg which in turn produces a giant individual. Morgan (1927, p. 466) suggests that two oöcytes may fuse early in growth, and then having only the nourishment of a single egg not grow beyond normal size.

On purely genetic evidence Whiting (1924, 1934) postulates the functioning of two maturation nuclei of the egg (pronuclei) to account for haploid mosaic males in the wasp *Habrobracon*. On similar data he shows that in the case of fertilized eggs either one or both of such nuclei may fuse with a sperm. Detailed

analysis of his data leads us to accept his postulate that the two nuclei are derived from the maturation nuclei of a single egg rather than from fusion of two oöcytes. Goldschmidt & Katsuki (1928) report both the cytology and genetics of a similar case in the Silk Worm Moth. Here it is produced by a recessive gene tending to form binucleate eggs, and the genetic evidence proves conclusively that two functional nuclei come from the egg in all cases. Doncaster (1914) had already found binucleate moth eggs cytologically, each nucleus accompanied by three polar bodies and being fertilized by a separate sperm nucleus. This is conclusive proof that in this case we are dealing with an egg containing two diploid nuclei, not with an egg in which two reduced (maturation) nuclei are functioning. Also Morgan and his coworkers (1914, 1919, 1923) show genetically that binucleate eggs are the most probable explanation of certain exceptional specimens of *Drosophila.*

In addition to the above cases there are the following definitely referred by the authors to the fusion of two oöcytes. In the wasp *Copidosoma* Hegner (1914b) claims that two oöcytes regularly fuse, one furnishing the nucleus of the mature egg, the other furnishing the germ-tract determinant. Patterson (1917, 1921, 1927) in dealing with closely related species does not mention this claim nor cite this paper of Hegner's. In agreement with earlier authors he describes the mature egg as arising from a single oöcyte, the germ-tract determinant originating from the nucleolus. Cappe de Baillon (1925, 1927) is the strong proponent of oöcyte fusion to give bi- and tri-nucleate eggs. According to him the determination process in the cortical layer of the egg of the phasmid *Carausius morosus* begins during growth of the oöcyte. If the fusion occurs sufficiently early or if the fusion planes happen to coincide a normal embryo will result, but if the fusion planes do not coincide an egg with two separately determined plasma regions will result. He finds all stages from normal embryos to two separate embryos within one egg. To corroborate this hypothesis he, as well as Zakolska (1917) and Tur (1920), has found various stages in the fusion of growing oöcytes within the ovary. Von Lengerken (1928) accepts Cappe de Baillon's hypothesis and describes several presumably additional

cases from the beetles *Carabus* and *Lucanus*. In these non-parthenogenic forms oöcyte fusion may result in the production of gynandromorphs.

Whether or not the origin is the same in all cases there can be no doubt that binucleate eggs occur in such widely separated groups as phasmids, moths, beetles, wasps and flies. In all the above cases the egg is reported as responsible, supernumerary sperm never functioning except when they unite with an egg nucleus. [Huettner (1927) shows that in *Drosophila* supernumerary sperm might conceivably function without fusion but his point is yet unproven.]

9. **Trinucleate eggs:** As with binucleate eggs there are at least two possible methods of origin of trinucleate eggs. Cappe de Baillon (1927) figures trinucleate eggs of *Carausius*, his figures indicating that they have arisen by the fusion of three separate oöcytes. Whiting (1934) postulates trinucleate eggs in *Habrobracon* because mosaic males bred from virgin females sometimes show three or even four possible combinations of maternal characters. He also reports one gynandromorph thought to have arisen from a trinucleate egg one nucleus of which became fertilized.

10. **Parthenogenesis:** There are some insects in which all individuals develop parthenogenetically from non-reduced eggs (giving only females); such parthenogenesis may be either constant or cyclic but is always obligatory. In Hymenoptera and certain other forms reduced but unfertilized eggs normally produce males. In other insects parthenogenetic development of reduced eggs occurs occasionally or can be induced. A detailed treatment is given by Weber (1933, p. 514) so only a representative set of cases is cited here.

Goldschmidt (1917) gives a detailed analysis of a case of facultative parthenogenesis in the Gypsy Moth. Clément (1917, 1921) reports that it is sometimes induced by centrifuging Silk Worm eggs. Bataillon & Su (1931a) report that it can be induced by chloroform or weak acids in Silk Worm eggs and that it frequently results in an activation superior to that of fertilization. Harrison (1933) and others have reported that it is sometimes induced by attempted hybridization. A peculiar case is reported

by Shull (1930a) for aphids. Here the mode of reproduction of an individual is determined before birth by external factors (light & temperature). It is the determination of the mode of reproduction of an individual by the action of factors upon its mother rather than upon the generation affected.

Slifer & King (1932) and King & Slifer (1934) report that in unfertilized eggs of the grasshopper *Melanoplus* the maturation divisions are completed at nearly the same rate as in fertilized eggs. The embryos developing from these eggs frequently contain both haploid and diploid cells. This, as well as genetic evidence from parthenogenesis in the grouse locusts (King & Slifer 1933), indicates that the maturation divisions are normal and that there is no fusion of a polar body nucleus with the true egg nucleus but that during cleavage there is a doubling of chromosomes without separation into two nuclei. The animals reared to maturity were all females. This, coupled with the fact that from thousands of unfertilized eggs several hundreds hatched but only about twenty lived to maturity, seemingly indicates that only those individuals which successfully attain a diploid condition live to maturity. Since the second generation gave results similar to the first the high mortality must be ascribed to the haploid condition itself, not to uncovered lethal genes.

V. CLEAVAGE AND BLASTODERM FORMATION

The insect egg is made up of a central yolk mass enmeshed in a slight cytoplasmic reticulum and surrounded by a relatively thin layer of dense cytoplasm—the cortical layer or periplasm. At the time of union of the sperm and egg nucleus the latter lies somewhere within the yolk region of the egg (its position probably being constant in any particular species). Due to this position and the centrolecithal yolk distribution, cleavage is of the superficial type in all the species treated in this review, *i.e.*, cleavage consists of nuclear divisions accompanied by division of only the small cytoplasmic area immediately around the nucleus (the so-called 'protoplasmic island'), true cell formation not occurring until the cleavage nuclei penetrate the cortical layer where they give rise to the multicellular blastoderm. [This type of cleavage is peculiar to the arthropods but is not universal among the insects.]

No development occurs if the early cleavage nuclei are killed by cauterization (Reith 1925, 1931b, Pauli 1927)—the formation of an enucleate 'blastoderm' in unfertilized eggs of *Phragmatobia* hybrids is an apparent exception (Seiler 1924, see Section V–B). Nuclei must enter the region of the activation center (*q. v.*) before differentiation of the germ band can occur in *Platycnemis* (Seidel 1932), but in *Camponotus* this center functions before it becomes nucleated (Reith 1932b). The cleavage divisions are not inseparably bound up with the early developmental processes since they continue for some time after elimination of the activation center (Seidel 1929b, Reith 1931b) or after blocking of all development by x-irradiation (Henshaw 1934).

A. Specialization of Nuclei

The cleavage nuclei are usually but not always indeterminate or totipotent at least until blastoderm formation (Sturtevant 1929, Seidel 1932). In *Platycnemis* Seidel (1932) reports that neither abnormal or delayed nuclear distribution nor elimination of one of the first two nuclei prevents formation of a normal embryo, nor does a decreased number of nuclei necessarily delay the onset of determination and differentiation. Equipotentiality of the nuclei is also indicated in the experimental results of Hegner (1908), Reith (1925) and Pauli (1927).

At first the cleavage divisions occur synchronously,[3] but sooner or later this synchrony ceases and heterochronous divisions begin, usually during blastoderm formation. Heterochronism may be regarded as the first indication of nuclear differentiation, but in some cases it is preceded by vitellophags being left behind in the yolk.[4] In *Platycnemis* the nuclei reach the surface between the fifth and sixth divisions but beterochronism does not set in until the tenth division. Seidel (1929b) reports that there is some indication that cleavage ceases after the last synchronous division when the activation center (*q. v.*) is eliminated. In *Ephestia*

[3] Synchrony of cleavage divisions has been reported in Apterygota, Orthoptera, Dermaptera, Aphidæ, Odonata, Coleoptera, Lepidoptera, Hymenoptera and Diptera (see Schnetter, 1934a, table 12). If the onset of a different division rhythm for the germ-tract nuclei be counted the number of synchronous divisions varies from three in *Miastor* to ten in *Apis*.

[4] Ordinarily the vitellophags arise from nuclei that migrate back into the yolk from the blastoderm. For a tabular summary of the data on vitellophag origin see Sehl, 1931, p. 570.

and *Apis* heterochronism begins with the tenth and eleventh divisions respectively, when the nuclei enter the cortical cytoplasm. Schnetter (1934a) describes the heterochronous division in *Apis* as proceeding in 'waves,' the mitoses occurring first in a definite region of the egg (see Section VII–B) and spreading successively to neighboring nuclei. In the Diptera those cleavage nuclei which happen to enter the germ-tract determinant region at the posterior pole of the egg cease dividing synchronously with the other nuclei as soon as they become segregated as 'pole cells,' although synchrony continues independently within each set of nuclei at a different rate from that in the other set. In the fly *Sciara* DuBois (1932) reports the elimination of whole chromosomes from all nuclei at the fifth division and prior to the segregation of the germ-tract nuclei, and further elimination during the seventh to ninth divisions from the remaining (somatic) nuclei after germ-cell segregation. In *Miastor* Huettner (1934) reports the elimination of three-fourths of the total number of chromosomes from the somatic nuclei during the third and fourth cleavage divisions and after the segregation of the germ cells (reduction from octoploid to diploid condition). In neither case is the division synchrony affected by this elimination. In *Camponotus* Reith (1931b) reports that after early destruction of the activation center, the usual zonation of the cortical layer does not occur and no true blastoderm is formed, yet the cleavage nuclei differentiate into visibly distinct types (embryonic and extra-embryonic). At present these various types of nuclear differentiation cannot be attributed to a common factor. Cytoplasmic influence seems operative in germ-cell differentiation in the Diptera and possibly in the described behavior in *Camponotus;* the developmental centers (Section VII) through their effect on cytoplasm, other oöplasmic constituents or nuclear migration, may influence division heterochronism in *Platycnemis* and *Apis;* whereas intrinsic factors in the nuclei themselves may be more directly responsible for chromosome elimination in the lower Diptera and for vitellophag formation.

B. Migration of Nuclei

In *Platycnemis* Seidel (1932) reports that the first four cleavage nuclei are oriented at intervals along the longitudinal axis (Fig.

1a). He says this is due to a strong repulsion tendency of the mitotic figures against one another and against the surface of the egg, the tendency becoming reduced as the nuclei and protoplasmic islands become smaller. He observed occasional cases of atypical distribution which he thinks due to an absence or failure of this tendency, but one would expect visible abnormalities in mitoses if such were true. Seidel also reports that the activation center (Fig. 1 a–b) is not concerned in nuclear migration since the distribution of the nuclei occurs almost or quite normally when this center is completely constricted off from the rest of the egg.

In the butterfly *Pieris* Eastham (1927) shows that the cytoplasm of the protoplasmic islands extends into the cytoplasmic reticulum of the yolk in the form of long tapering strands distributed around the nucleus. Via these strands the cytoplasm of the protoplasmic islands is continuous with that of other islands and of the cortical layer. Therefore the egg is a true syncytium with each nucleus lying in the center of a small cytoplasmic area. As cleavage begins the mitotic figures are oriented at random and result in a cluster of nuclei. The first indication of their migration is the formation of a small hollow sphere of nuclei. In this sphere subsequent nuclear divisions occur parallel to the surface with the result that the spherical arrangement is maintained. Concerning the migration itself Eastham believes the nuclei are moved passively through the yolk by centrifugal streaming because, (1) flecks of cytoplasm are frequently seen elongated in the direction of nuclear movement; (2) the comet-like tails of the protoplasmic islands stretching out behind the migrating nuclei are also present during mitosis when the nucleus is not thought of as active; (3) as the nuclei approach the cortical layer the intervening area becomes visibly richer in cytoplasm, and (4) conversely the area within the nuclear sphere becomes poorer in cytoplasm. In addition he notes that the nuclei are first nearer the cortical layer in the lateral and anterior regions but that then the posterior nuclei move more rapidly thereby changing the shape of the nuclear sphere (first reach surface antero-ventrally). During this time each nucleus moves to the peripheral end of its protoplasmic island, and, as it enters the cortical layer, becomes

elliptical with its longitudinal axis parallel to the egg surface (evidence of pressure between nucleus and cortical layer). The comet-like tails are then drawn in and spread out to fuse with one another enclosing a thin layer of yolk peripheral to their points of fusion. This visibly distinct cytoplasmic layer is called the 'inner cortical layer.' Sehl (1931) reports fundamentally the same for the moth *Ephestia*.

In the Honey Bee Schnetter (1934a) divides the kinematic appearances into three phases: (1) first four divisions near the anterior pole with successive spindles at right angles to one another (Sach's Law) and giving first a quadrant then a hollow sphere of sixteen nuclei; (2) fifth to seventh divisions in a longitudinal direction, tangential to the surface of the elongating sphere, the center becoming almost devoid of cytoplasm, the periphery rich; and (3) migration to the cortical layer during the seventh to tenth divisions, the movement being most rapid in the widest region of the egg and toward the ventral side. The first vitellophags arise by radial division of one or two nuclei during the seventh division, and are described as moving inward against the general outward movement. He refuses to commit himself as to how the nuclei move but it certainly is not merely a repulsion tendency of the mitotic figures.

In the ant *Camponotus* and the beetle *Sitona* Reith (1931b, 1935) reports that early elimination of the activation center does not affect nuclear movements despite the fact that this center normally functions during cleavage.

In *Calliphora* Strasburger (1934) reports that an oval sphere of nuclei is formed at the sixteen-nuclei stage. During metaphase each mitotic figure lies tangential to the surface of this sphere, but during telophase, when no spindle fibers are apparent, the daughter nuclei move in a radial direction in such manner that the mitotic axis bends and the nuclei lie at an acute angle to each other until completely separated. In this connection it is seen that the position of the nuclei at the peripheral end of the protoplasmic islands is correlated with mitosis—the spindle is at the center during metaphase, at the peripheral margin during telophase. The nuclei enter the cortical layer synchronously, but this synchrony of movement is not especially important since

disturbances in it merely result in part of the embryo anlage developing sooner than the rest, a normal embryo being eventually formed. Strasburger suggests that the protoplasmic streaming is due to active movement of the protoplasmic island or its parts since in lightly cauterized eggs no such streaming is visible in non-nucleated but "uninjured" parts of the egg. However formation of the inner cortical layer is clearly a plasma streaming without nuclear influence for when the nuclei are delayed the cortical layer thickens prior to their entrance (greater ventrally than dorsally). In *Drosophila* Huettner (1935) says that there are three types of movements: (1) first eight divisions resulting in the even distribution of 256 nuclei throughout the egg; (2) movement into the cortical layer; and (3) movement of the posterior nuclei in the formation of the germ cells. He thinks that the first type of movement is "partially conditioned by the mitotic spindle," though other factors must be involved since the nuclei continue to move slightly when spindles are not present [viscosity changes concurrent with mitosis might be a factor here]. He offers no explanation of the second type, but refutes the possibility of protoplasmic streaming because of vitellophags being left behind. He thinks the third type probably due to a combination of spindle action and protoplasmic flow.

Analysis of the motivating factor or factors in these nuclear movements is difficult because of the inability to separate cause from effect in observational data. There is certainly no amœboid movement exhibited by either nucleus or protoplasmic island. The movement is not impeded by repeated mitoses during migration, in fact, Huettner (1935) says movement may in certain cases be accelerated during mitosis in *Drosophila.* The movement of the centrioles during mitosis shows that they cannot be the causative factors even though they constantly lie towards the egg-periphery in undividing nuclei (Huettner 1933, Strasburger 1934). The repulsion tendency cannot possibly function to cause centrifugal movement of the nuclear sphere.

There remain three possibilities: (1) active nuclear movement which pushes the cytoplasm in front of it and draws that behind; (2) plasma streaming which carries the nuclei along passively, and (3) some unknown attractive influence from the surface

region. The only observation that can be considered in favor of the first hypothesis is Strasburger's report that plasma streaming does not occur in non-nucleated but seemingly uninjured parts of the egg of *Calliphora*. But this is by no means conclusive evidence even for this species since he does not consider such questions as the possible failure of local activation, altered viscosity or other possible invisible physico-chemical changes in these cauterized eggs. He attempts to circumvent the difficulty of ascribing active nuclear movements to the nucleus by suggesting that the movement is due to the protoplasmic island in whole or part, but this is unsupported and also conflicts with his own data on the formation of the inner cortical layer and with Seiler's data to be discussed below. Another possibility that has not been suggested by any previous author is that the qualitative differences between the various nuclei, as expressed by the non-migration of vitellophags, might conceivably result in surface-tension phenomena around each nucleus. Such differences, arising from differences in the nuclei themselves, might possibly inaugurate the general plasma streaming and also cause the differences between the movements of various nuclear-types, perhaps largely by causing the vitellophags not to participate in the general outward movement or actually to move against it. In favor of the second hypothesis, plasma streaming, there are two positive observations. (1) Strasburger's report that when some of the nuclei anterior to the point of cauterization are delayed from entering the cortical layer in eggs of *Calliphora* the inner cortical layer is formed in those regions before the nuclei reach it. (2) Seiler's report (1924) that the eggs of *Phragmatobia* (moth) hybrids occasionally undergo 'cleavage' of the cortical layer to form a pseudo-blastoderm even though no cleavage nuclei are present in the egg. His illustrations show clearly that those areas which undergo this 'cleavage' process have a considerably thickened cortical layer. Both of these cases certainly represent a plasma streaming without nuclei, from which it is reasonable to assume that the plasma streaming is the primary factor in these movements. But plasma streaming alone leaves unexplained those cases where vitellophags are left behind in the yolk (unless the plasma streaming is local and caused by

the nuclei—its general appearance being due to a summation of local effects around each nucleus. See above). The third hypothesis is indefinite. It is included here partly as a possible answer to the occasional non-migration of vitellophags, partly as a possible source of origin of the plasma streaming (see below).

The factor or factors causing the centrifugal migration of the nuclei must be the same that bring an end to the random orientation of the mitotic figures and arrange the nuclei in the form of a hollow sphere. It would seem that only a centrifugal plasma streaming could accomplish this. But from what could such a plasma streaming originate? Certainly not directly from randomly oriented nuclei. Perhaps it is unwise to attempt delimitation to any single factor or part, but it seems possible that the stimulus might arise from the distant influence of the cortical layer. The original shape, later movements and change of shape of the nuclear sphere are not too well correlated with the original thicknesses of the various regions of the cortical layer so it can scarcely be a truly quantitative relationship. Nevertheless Schnetter (1934a, p. 161) points out that there are certain quantitative correlations in the Honey Bee egg. He describes the outward movement of the nuclei as occurring in waves passing anteriorly and posteriorly from the region of the differentiation center (*q. v.*), the nuclei first reaching the surface anteriorly and ventrally near the locus of polar-body formation, and suggests that a motivating impulse is transmitted from the differentiation center following the release of the qualitatively distinct "Richtungsplasma" into the periplasm. There are, then, two possible origins of this centrifugal movement, both hypothetical: (1) a more or less general effect from the cortical layer, or (2) qualitative differences not necessarily included in the developmental centers although sometimes correlated with the differentiation center. Either is substantiated but not proven by Strasburger's observation that light cauterization of the egg of *Calliphora* frequently results in a displacement anteriorly of the nuclear sphere. If either of these suggestions is true, then the origin of the plasma streaming is one of the first indications of the activation of the *general* dynamic egg system[5] (see Section

[5] In a sense vitellophags left behind in the yolk form an exception here as was noted in the last paragraph. But, just as they are sometimes visibly

VII–C). Whether such influence acts by changing concentration gradients or by some other means is totally unknown. In this connection we might add that Hegner (1909) has shown that the contents of Chrysomelid beetle eggs are more easily stratified by centrifugal force during late cleavage than at any time before or after. Presumably the egg contents are less viscous at this time. Also Pauli (1927) notes that after reorganization of the disarranged egg contents the nuclei come to lie near the boundary between zones or distribute themselves evenly over the surface of the egg.

It should also be noted that in the indeterminate-type eggs of *Platycnemis* and *Tachycines* further migration occurs after the nuclei are uniformly distributed over the surface. The cells assemble in two groups (ventral in *Platycnemis,* dorsal in *Tachycines*) which finally come together on the ventral side of the egg to form the embryonic rudiment (Seidel 1929b, Krause 1934). This peripheral migration, at least in *Platycnemis,* is caused by a contraction wave in the yolk system (see Section VII–B), and hence is passive. In more determinate types of eggs (*e.g.* moth, bee, etc.) the embryonic rudiment arises by differential thickening of the blastoderm, not by cellular migration.

C. Stimulation to Blastoderm-Cell Formation

Seidel (1932) reports that if the activation center (*q. v.*) is eliminated in *Platycnemis* by constricting the egg, there is a delayed formation blastoderm of extra-embryonic type anterior to the constriction. Reith (1931b) reports a somewhat similar state of affairs in *Camponotus,* where if the activation center is eliminated immediately after fertilization the nuclei reach the

distinct, so too there must be some intrinsic difference between vitellophag and blastoderm nuclei. Since plasma streaming is a proven fact and in at least some cases has a definite relation to blastoderm formation (see Section V–C), we prefer for the present to consider nuclear movement as passive and these vitellophag cases as exceptions to the *general effect* of plasma streaming rather than as absolute refutation of any causal significance of the streaming. Another possibility is that the intrinsic nuclear differences result in local surface tension phenomena at the surface of the various nuclei and so influence the plasma streaming in their own immediate vicinity or the movement of the particular nuclei in this streaming.

surface of the egg but are incapable of blastoderm formation, nevertheless they undergo differentiation into embryonic and extra-embryonic types.

Eastman (1927) reports that in *Pieris* the nuclei enter the cortical layer perpendicularly and move outward through the cortical layer to protrude beyond. It is difficult to say whether this protrusion is due to continued outward movement of the nuclei or to withdrawal of the cytoplasm between them. At this time the cytoplasm of the cortical layer can still be distinguished from that of the protoplasmic islands, and it is from the outer part of the cortical layer that the cell walls begin to develop. By this time the 'tails' of the protoplasmic islands have been drawn in and fused with those of neighboring nuclei to form the inner cortical layer. The cell walls now grow inwards between the nuclei; the basal membrane is then formed through the center of the inner cortical layer dividing it into two thin layers. The walls begin to develop anteriorly where the nuclei first enter the cortical layer, and are completed ventrally before dorsally.

Seiler (1924) reports a case in the eggs of *Phragmatobia* (moth) hybrids that has remained unique among insects. These eggs were presumably unfertilized since no sperm could be found and the egg nucleus, which remained lying at the point where the two nuclei usually fuse, soon disappeared and left only the protoplasmic island to mark its former position. Such eggs frequently ("hundreds") underwent partial or complete division of the cortical layer into blastoderm cells of fairly normal appearance but without nuclei. He found all stages from early division to a complete 'blastula,' and his photos leave no question of the authenticity of his observations. It is of particular interest that the division was not uniform throughout the egg but was quite 'spotty.' The parts of the cortical layer that divided became thickened (as in normal eggs) in contrast to unthickened in undivided parts and in eggs that did not develop. There is, then, a definite correlation in this case between the thickening of the cortical layer and its division into 'cells.'

Schnetter (1934a) reports that the Honey Bee is very similar to *Pieris,* differing principally in that the basal membrane is formed before the formation of the inner cortical layer. It soon

disappears, the inner cortical layer is incorporated into the blastoderm, and then the basal membrane is re-formed.

Experimentally Strasburger (1934) shows that there is a definite time relation between the entrance of the nuclei into the cortical layer and the formation of cell boundaries in *Calliphora*. Normally both occur synchronously throughout the egg, but when the nuclei enter the cortical layer first at the anterior end (either abnormal distribution or experimental hindrance) the cell boundaries also form there first. [This time relation is also seen in cases where the nuclei do not enter the cortical layer synchronously, *e.g.* first reach surface ventrally in *Ephestia* (Sehl 1931), antero-ventrally in *Picris* (Eastham 1927), etc. In these cases the cell walls form first in those parts where the nuclei first reach the surface.]

From the above data four points are noteworthy: (1) Seidel's and Reith's observations that delay in (*Platycnemis*) or failure of (*Camponotus*) cell-wall formation occurs after elimination of the activation center; (2) Eastham's observation of the formation of cell boundaries from the cytoplasm of the *original* cortical layer; (3) Seiler's observation of 'cell' formation without nuclei but with a thickening of the cortical layer; and (4) Strasburger's demonstration of the formation of cell walls at a definite time after entrance of the nuclei into the cortical layer. The first suggests that cell formation is aided or determined by the activation center; the second might be interpreted as suggesting that there is a predetermination of the cortical layer to form cells; the third must be interpreted as either a partial activation causing both localized streaming and cell formation or as a partial activation causing streaming which in turn causes cell formation; and the fourth suggests that cell formation is wholly a function of the nuclei. The natural assumption is that all these factors are involved but that they have different potencies in different insects.

VI. THE INDETERMINATE–DETERMINATE SERIES

By differences in the time of appearance of the visible morphological characteristics of development, especially the germ

cells, Seidel (1924) showed that it is possible to establish a series ranging from indeterminate through incompletely determinate to determinate types. In indeterminate eggs the visible separation of regions of different prospective significance occurs after blastoderm formation, and organ segregation follows after differentiation of the germ layers and segmentation. In determinate eggs this visible differentiation occurs before or during blastoderm formation.

Following this lead experiments were devised by Seidel and his students to determine if this series is also illustrative of the potencies of the egg parts as determined by the regulative power or conversely the degree of predetermination of the egg parts. These studies have shown that Seidel's series is fundamentally accurate both for visible differentiation and for the degree of predetermination of the various egg parts. From both viewpoints it is a matter of time (time or stage of visible differentiation and time of determination), indeterminate eggs becoming more and more determinate as development proceeds, determinate eggs being fully determined by the time of fertilization. Schnetter gives the following revised scheme:

Indeterminate — Incompletely Determinate — Determinate

Odonata—Hemiptera—Orthoptera—Coleoptera—Hymenoptera—Lepidoptera—Diptera.

Whether or not Schnetter is justified in listing the above sequence seems open to question. In the first place no experimental data are available for either the Hemiptera or the Lepidoptera, and these two orders are placed in the series wholly on a basis of the time of visible differentiation of the various parts. A more serious criticism lies in the implication of homogeneity within single orders. Experimentally only a single species of Odonata has been studied, two Orthoptera, two higher Hymenoptera, three Coleoptera and three higher Diptera. As will be pointed out below there is good reason to expect considerable variation within the order Hymenoptera, polyembryonic forms seeming to be highly 'indeterminate.' Perhaps similar variation will be found within other orders.

Indeterminate eggs have a certain amount of determination at the time of fertilization. Bilaterally symmetrical ones have

the polarity and dorsal and ventral sides irrevocably determined. In the absence of experimental data it is not possible to evaluate the variation in position of the embryo of the radially symmetrical egg of the bug *Pyrrhochoris* (see Section III); though the embryonic axis varies through 90°, it is not possible to say whether its position is determined before, during or after fertilization. Except for the fundamental axes indeterminate eggs possess great regulative powers as shown by dwarf embryos and duplications. Experimentally produced twins and duplicated parts show that there is in the early blastoderm a specific disposition of materials for the formation of the germ band but that when these materials are separated each part tends to form a whole structure rather than only an isolated part. This power becomes more limited as development proceeds, but studies on regeneration show that the power of regulation is not entirely lost until the adult stage (see Part II).

In *Platycnemis* Seidel (1928, 1929a) reports that shortening the longitudinal axis by constricting the egg results in dwarf but otherwise normal embryos. Duplications which result from splits induced by cautery also show that the prospective potency of the egg parts is greater than the prospective significance at the time the various anlagen are set apart; each duplicated part is larger than one-half the size of the same organ in a normal embryo, so that the sum of the two duplicated parts is greater than the size of a single normal organ. This power of duplication is possessed by all organs, external and internal. It never occurs in the longitudinal axis, seldom in the dorso-ventral axis, but commonly in the transverse axis. The interpretation given is that determination occurs in these three axes in this same order. In *Tachycines* Krause (1934) reports a correlation between the type of mechanical injury to the germ band and the effect. Frontal fissures give duplications in the dorso-ventral axis, median and oblique fissures of various extents and positions give symmetrical or asymmetrical, transverse anterior or posterior duplications or parallel twins (division of differentiation center ?), and fine splits give duplications of single organs. Effects produced by operating at different stages show that determination of the main axes is followed by determination of segments

in the longitudinal axis, then of the lateral halves within these segments, and finally of individual organs. Oka (1934) reports preliminary experiments showing only that the egg of the cricket is of the regulative type.

An interesting observation is made by Cappe de Baillon (1925, 1927). Because he has shown that "double monsters" of phasmids (Orthoptera) most probably originate from the fusion of two eggs, he suggests that the oöcytes were partially determined before fusion so that the determined parts of the cortical layer did not fuse completely into a single embryo. He reports that the chance of any given organ being double is correlated with its nearness to the procephalic lobes—the more anterior the more frequently double. This suggests to us that the determination process in the cortical layer of the growing oöcyte begins at or near the anterior end and proceeds posteriorly, the great regulative power of the indeterminate egg permitting fusion of the less determined regulative power of the indeterminate egg permitting fusion of the less determined parts (posterior regions) but not of the more determined parts (anterior regions). Naturally the reverse is true for the experimental production of twins and duplications. An alternative view would consider this the result of the incomplete or dissimilarly oriented fusion of two differentiation centers (Schleip 1929).

Slifer (1934) shows that dechorionated grasshopper embryos can withstand a lowering or 10 per cent or raising of 30 per cent of the osmotic pressure without noticeable effect. A 0.3n Ringer's solution has about the same severity of effect as a 3n Ringer's, but embryos will survive many hours in both and in even more anisotonic solutions. Within certain limits the changes are quickly reversible on return to normal Ringer's. Comparison with *Drosophila* suggests that this may be another criterion of indeterminacy.

Incompletely determinate eggs are intermediate between the two extreme types. They are capable of considerable regulation following experimental interference in early stages, but the power is lost much sooner than in indeterminate eggs. Dwarf-formation has been observed but not duplication of parts. The absence of duplications indicates that strict determination of the presumptive anlagen occurs early.

In the Hymenoptera Schnetter (1934b) reports that constricting the Honey Bee egg at the stage of the "uniform blastoderm" (12 hour embryo) can result in a normal dwarf embryo. Later blastoderm stages (24 hour embryo) are less labile and more inclined to mosaic formation with a shift in the regions of different prospective significance (Fig. 2). In the ant *Camponotus* Reith (1931b, 1932b) shows by cauterization and constriction that the egg possesses considerable regulative power until the completion of the visible zonation by differential thickening of the cortical layer (presumably under influence of the activation center). After that it is determinate though not as highly so as dipterous eggs. By centrifuging he shows that stratification of the egg parts prior to the cortical zonation blocks development but later centrifuging does not prevent formation of a fairly normal germ band. These two sets of data show that within this order there is a difference in the time of determination, that of the ant occurring noticeably earlier than that of the Honey Bee. Though there are no experimental data involved, polyembryony (the production of two or more, sometimes several hundred, embryos from a single ovum by division of the cleavage cells into groups) in parasitic Hymenoptera must be viewed as positive evidence of a high degree of regulative power.

In the beetle *Bruchus* Brauer & Taylor (1934) show by constriction and cauterization that determination occurs quite early, the egg becoming a true mosaic during blastoderm formation. In *Sitona* Reith (1935) reports that the determination process occurs slightly later than in the ant and seemingly at about the same time as in the Honey Bee. In Chrysomelid beetles Hegner (1908, 1909, 1911) performed a series of experiments using puncturing, cauterization and centrifugation but his results seem open to some question, partly due to the extreme nature of injury inflicted upon the egg. He claims that when the germ-tract determinant region or the 'pole cells' are removed or killed no germ cells are found in the larva (this seems probable, see Section X), and that the egg shows no regulation during cleavage, blastoderm or later stages, *i.e.*, that it is strictly mosaic from the time of laying. Some of the results of centrifuging these eggs resemble those obtained with *Camponotus*, normal embryos (sometimes displaced) de-

veloping only in eggs centrifuged during the blastoderm stage or later, though one centrifuged female *Leptinotarsa* laid stratified eggs which developed normally. In all these beetles the investigators agree in saying the eggs are completely determined (mosaic) after the formation of the blastoderm.

Determinate eggs have been found only in the Diptera but at least as far as the germ cells are concerned Hegner's results indicate that the Chrysomelid beetles might also be placed here (and also the other insects in which the presumptive germ cells are segregated as 'pole cells' during blastoderm formation). Determinate eggs always give mosaic formations under experimental conditions, the few slight exceptions showing an extremely small amount of regulative power. Accordingly the parts of the embryo must be looked on as entirely self-differentiating after fertilization, or, at least, incapable of development beyond their prospective significance.

Reith (1925), Pauli (1927) and Howland & Robertson (1934) report that cauterization of dipterous eggs invariably gives mosaic development. Slight regulative power is shown by Reith's report that the midgut anlagen of either end may form an entire midgut, and also by Strasburger's (1934) report that slight cauterizations at the beginning of cleavage may delay the migration of the cleavage nuclei to the posterior part of the egg without preventing formation of a normal embryo—the posterior parts developing slightly later than the anterior parts. Sonnenblick (1934) and Howland & Child (1935) show that puncturing does not necessarily prevent the development of normal embryos and larvæ although the adults may exhibit injuries. The high mortality and uncertainty as to the exact nature of the extruded materials make their data difficult to interpret under this section. On a basis of ultra-violet irradiation of oriented *Drosophila* eggs Geigy (1931b) postulates two determination periods in the eggs of higher Diptera: (1) an embryonic determination process completed not later than the time of fertilization, and (2) an adult determination process *via* the presumptive imaginal discs in later embryonic life. This will be discussed later.

Howland & Robertson (1934) report that dechorionated *Drosophila* eggs develop normally in "sea water diluted with tap

water to 33 per cent." They do not mention the effects of other solutions or concentrations but Howland (1932) reported that *Drosophila* sperm are highly sensitive to the constitution of the medium. The solution used for eggs is the same as that she found most satisfactory for sperm.

Cytoplasmic determination: It is evident that the distinction between 'regulative' and 'mosaic' eggs in insects, as in other groups, is not sharp, and the designations mean little unless the period of development is specified. The earlier an egg assumes a mosaic nature the 'more determinate' it is, but even the most 'indeterminate' of insect eggs eventually becomes 'determinate.' Sections V and VI show also that the primary seat of the chemodifferentiation (predetermination) is the cytoplasm as a whole, and that the formation of cells plays only a secondary or indirect part. The fact that development is less disturbed by late than by early centrifuging (Hegner 1909, Pauli 1927, Reith 1932b) suggests that fixation of determination is accompanied by increased cytoplasmic rigidity (viscosity) either before or after cell-formation.

VII. DEVELOPMENTAL CENTERS

A. The Activation Center

Seidel (1929b) has used the term "Bildungszentrum" to designate a region situated near the posterior pole of the egg and necessary for development. As we shall show this center is responsible for the activation of the egg system, and so it is here designed 'the activation center.'[6] The literal translation, 'formative center,' is ambiguous and may carry unwarranted implications. It is not a visibly distinct part of the egg but can be more or less closely delimited by experiments. It functions by the production of some substance which diffuses forward through the interior of the egg and initiates development. In its absence no true differentiation of the embryo occurs. To date it has been demonstrated in five species of insects (a damsel fly, two ants and two beetles).

The activation center has been most elaborately analyzed in the damsel fly *Platycnemis* by Seidel (1926–1934). In this species (Fig. 1) the anterior border of the activation center coincides

[6] This term has already been used by Huxley & DeBeer (1934).

approximately with the presumptive posterior end of the embryo (about 1/9th the length of the egg from the posterior pole) but its posterior extent is undetermined. The point at which the germ band later invaginates into the yolk marks its locus (see Section VIII). Here the functioning of the activation center depends upon an interaction between the cleavage nuclei and the region of this center. This is demonstrated by numerous experiments:

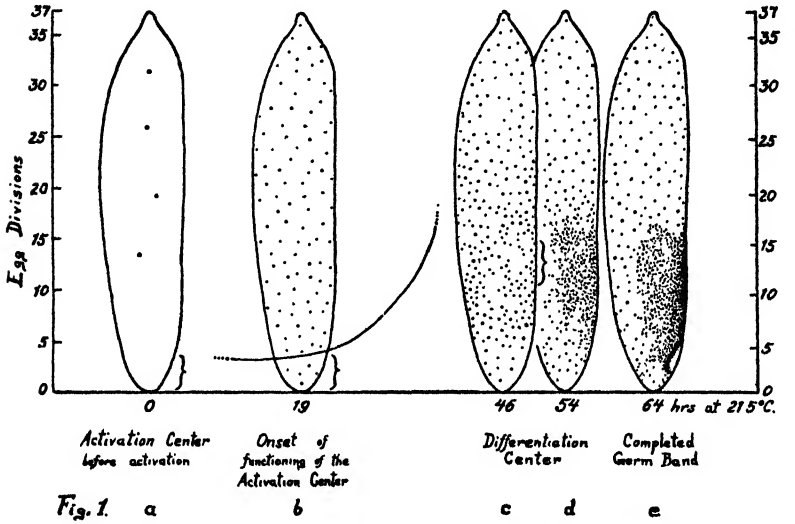

Figure 1. Graphic diagram of the development of the egg of the damsel fly *Platycnemis*. *a* 4-nuclei stage with bracket indicating the position of the activation center. *b* 256-nuclei stage with curved line indicating the diffusion anteriorly of the product of the activation center. *c* Beginning of cell-aggregation with bracket indicating the position of the differentiation center. *d–e* Formation and completion of the embryo anlage. 1 egg division equals 24 μ. (After Seidel, 1934.)

when the cleavage nuclei are late in reaching this region either due to abnormal distribution, killing of one of the first two cleavage nuclei with ultra-violet light, or constricting the egg and later removing the constriction, the functioning of this center is delayed. Careful comparison with normals shows that none of these delays causes any effect on later development other than delaying the onset. If, however, the cleavage nuclei are prevented from entering this region by a constriction of the egg no

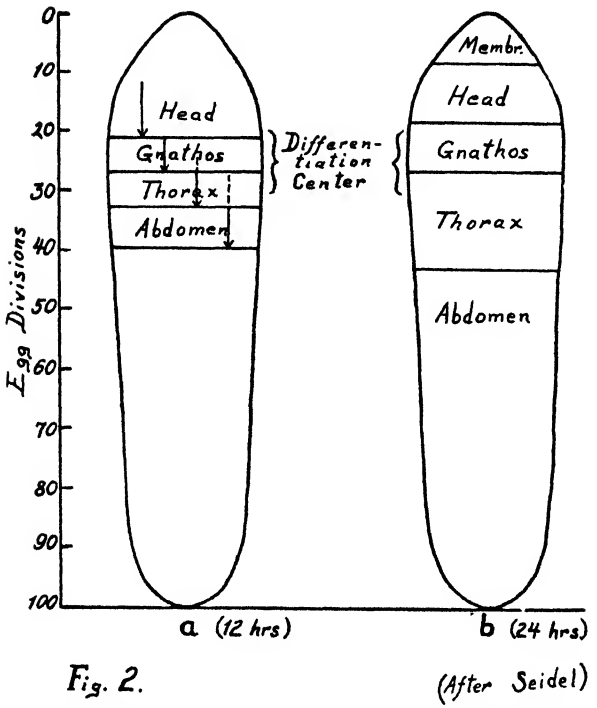

Figure 2. Schematic anlagen plan of the Honey Bee egg. *a* Posterior boundaries of the *potency regions* ("... those regions of which a small part must remain in the egg to enable the formation of the entire corresponding organ region") in the 12-hour blastoderm. *b* Expansion of the same regions along the longitudinal axis in the 24-hour blastoderm. (After Schnetter, 1934b.)

development ensues although the anterior parts continue to live, undergo 'yolk cleavage' and eventually form an extra-embryonic blastoderm. Partial constrictions show clearly that it is the nuclei which must reach this area, not some chemical which can diffuse through the yolk system. The reaction is not limited to the surface of the egg (which lacks a distinct cortical layer) since peripheral parts in the region of the center may be killed by ultra-violet light without preventing normal development. Finally, the removal of constrictions and constricting after the nuclei enter this region both show by the production of embryos that the injury to the egg does not block development. There-

fore we must conclude (1) that the egg contains two quantitatively or qualitatively different regions (compare animal and vegetal poles of other eggs), and (2) that neither the cleavage nuclei and their cytoplasm nor the activation center is capable of producing a normal or even partial embryo alone, but that they react together to furnish a product which allows normal development to proceed along axial and symmetrical lines that have already been laid down.

Seidel further shows that after the nuclei have entered this region, more and more can be constricted off from the posterior end of the egg without blocking development. The action of the center spreads slowly over a considerable area so that well before the assembling of cells to form the germ band its effect has been felt over the entire presumptive germ band (see curved line in Fig. 1). The interaction product must diffuse forward through the yolk system since a partial constriction after the nuclei reach the activation center does not prevent an embryo being formed anterior to the constriction. In some eggs there is a visible change in the structure of the yolk proceeding apace with the diffusion of factors from the posterior pole anteriorly. Further, this product activates the differentiation center which will be discussed below.

In the ant *Camponotus* Reith (1931, 1932) shows by constriction and cauterization that an activation center is present near the posterior pole but he has not delimited it closely. In this species it differs from *Platycnemis* in that the cleavage nuclei are not responsible or even necessary for its functioning. Its activation must be induced by some product concerned in fertilization, presumably produced not later than the time of fusion of the egg and sperm nucleus since the visible effect of the functioning of the activation center is seen in very early cleavage stages. This product must diffuse through the yolk system just as the product of the activation center does since neither is impeded by partial constrictions, yet obviously they cannot be the same substance. Another interesting difference from *Platycnemis* is that the activation center in this species induces a visible zonation (differential thickening) of the cortical layer prior to the migration of the cleavage nuclei. This visible differentiation begins at

the posterior pole and passes slowly to the anterior end of the egg as does also the 'activating power.' Attempting to localize the activation center to some visibly distinct part of the posterior region of the egg he noted that the disintegration of the 'pole-disc' is correlated with the action of this center. The 'pole-disc,' however, can not be the essence of the center since it is lacking in the ant *Lasius* which gives similar experimental results. Nor can the effect be traced to the bacterial symbionts since their injury is not correlated with that of the embryo. [It is interesting to note that Hinman (1932) shows various bacteria present in a small percentage of mosquito eggs without seeming effect on the embryos, and Scheinert (1933) discusses their presence and perpetuation in various insects.] As in *Platycnemis*, the activation center must be ascribed to an invisible difference in the egg regions.

In the beetles *Bruchus* and *Sitona* Brauer & Taylor (1934) and Reith (1935) report the presence of an activation center in the posterior region of the egg. In both of these beetles the functioning of this center begins during cleavage and is finished when the nuclei enter the cortical layer (*i.e.*, later than in ants). Unfortunately these are both rather preliminary reports and analyses must be made with care. In *Bruchus* Brauer & Taylor report that when the constriction is made sufficiently early to exclude nuclei from the posterior end of the egg, the anterior portion forms "only a poorly developed blastoderm," yet "a protoplasmic isthmus . . ., however narrow it may be, serves to conduct the organizing principle anteriorly." Hence it would seem that the nuclei are necessary for the functioning of the activation center in *Bruchus* as in *Platycnemis*.

B. The Differentiation Center

The visible differentiation of the insect embryo begins in the presumptive prothorax, and from this region proceeds anteriorly and posteriorly. Descriptive embryology shows that the spread of differentiation from the thoracic region is a general principle of insect development,[7] and, as Schnetter (1934a) points out, may

[7] Schnetter (1934a, table 12) gives a comparative table including representatives of all the major orders.

be considered as typical of insects as is superficial cleavage, though there may be exceptions in regard to both (in other arthropods and annelids, differentiation begins in the head). There is evidence that this also applies to pupal development. Seidel speaks of "das morphologische Differenzierungszentrum" and "das physiologische Differenzierungszentrum," but since these two terms denote distinct concepts it is deemed preferable in this paper to avoid this terminology, although, in general, Seidel's treatment is followed. The term 'differentiation center' is here restricted to a physiological concept and is not applied to the visible starting point of differentiation, even though physiological and morphological phenomena normally occurring at a common locus may at times appear to be experimentally separable.

In *Platycnemis* the region where the two rows of assembled nuclei first come together to form the germ band marks the place from which all later differentiation proceeds anteriorly and posteriorly; it lies in the presumptive thoracic region, about one-third the length of the egg from the posterior pole (Seidel 1926, 1929b, 1934). In the Honey Bee (Schnetter 1934a) the visible embryonic differentiation begins near the anterior end of the egg (presumptive cervical region) at the site of polar-body formation, where the cortical layer is thickest, reticular cytoplasm is most concentrated, cleavage nuclei become most numerous and first reach the surface, vitellophags first appear, heterochronous mitoses first set in, and cell-partitions are first formed. A qualitative distinction of this region during cleavage is indicated by differential staining with thionin but not with haematoxylins. This region also has precedence in all later differentiation (formation and closure of mesodermal furrows, segmentation, appearance of appendages, etc.). A similar region is evident in *Ephestia* (Sehl 1931) but here the proctodæum forms before the stomodæum, 'yolk cleavage' progresses from posterior to anterior, and dorsal closure of the body wall is completely last on the mesometathoracic boundary. Eastham (1927) describes the differentiation processes in *Pieris* as occurring "from before backwards." Spread of morphological differentiation from a definite region is not so evident in the eggs of higher Diptera.

Experimental methods have demonstrated, as one might expect, that this region of initial morphological differentiation is of fun-

damental physiological significance, incorporating the so-called 'differentiation center.' The results of constricting *Platycnemis* eggs (Seidel 1934) show that this center normally coincides with the starting point of morphological differentiation though seemingly this morphological manifestation can be experimentally separated from the primary physiological center. The differentiation center extends from the second gnathal (maxillary) segment to the second thoracic segment with its midpoint in the anterior half of the presumptive prothorax (Fig. 1c, 4a).

Seidel (1929b, 1931, 1934) further shows that no differentiation can occur in an isolated region of the egg of *Platycnemis* unless the differentiation center is present in whole or in part. The center can function only after the product of the activation center has reached it by diffusion. It does not affect blastoderm formation but does directly influence the assembling of blastoderm nuclei and heterochronous divisions in germ band formation, although heterochronous divisions alone occur when almost the entire center is tied off. Unlike the activation center, the differentiation center cannot function normally with even a relatively slight constriction of this region of the egg. A very loose ligature outside the boundaries of this center will allow the formation of the germ band on both sides of the ligature, but if it is only slightly tighter, even though the blastoderm and yolk remain unsevered, the germ band forms on one side only. Since no continuity is destroyed in any part of the egg by such a constriction, the center's action cannot depend solely upon the spread of a substance but must involve an energy transfer, *i.e.*, must be a dynamic phenomenon. Cell aggregation to form the germ band is not prevented by killing a complete girdle of blastoderm cells over the entire region of the center (by ultra-violet irradiation). Initiation of this process must therefore originate in the 'yolk system,' viz., the yolk with its included cytoplasmic reticulum and vitellophags. Localized contractions of the surface of the yolk system, produced by cautery or point-irradiation before or during the time of cell aggregation, result in changes in the length, shape and position of the embryonic rudiment. The spaces between the yolk and chorion thus formed, or resulting when a ligature is loosened, serve as foci for cell aggregation which can thus be

artificially and prematurely produced outside the normal region. These data indicate that the direct action of the differentiation center is due to a wave of contraction in the yolk system spreading anteriorly and posteriorly from the center, the yolk system retracting from the chorion in such a way that the evenly distributed blastoderm cells are forced to fill the resulting space. In this manner cells first aggregate in the region of the differentiation center, and the size and shape of the germ band is molded by the space between yolk and chorion. This makes it clear how the differentiation center can be the center of a field of activity without necessarily involving the actual transport of any material substance, the result of constructions being due to interference with yolk movements. Additional proof of the dynamic nature of the differentiation processes in *Platycnemis* is furnished by the fact that killing a girdle of cells by ultra-violet irradiation either in front of or behind this region where visible differentiation normally begins causes a corresponding shift (backwards or forwards respectively) of the position of the initial differentiation. The yolk system is in effect temporarily reduced in size and the visible differentiation begins in the same relative position within the new system that it held in the larger system. If, then, the differentiation center is a definite region within the egg (as it seems to be), it must remain at one end of the reduced system while its action originates in a new location.

In the Camel Cricket *Tachycines* (Krause 1934) the order of decreasing regulation ability (lost earliest by the thorax), the relative frequency of organ-duplications (least often in prothorax), and certain asymmetrical duplications show that differentiation along both longitudinal and transverse axes proceeds anteriorly and posteriorly from the first thoracic segment. He suggests that the presence of a differentiation center may account for the non-occurrence of doubling along the longitudinal axis.

The results of constricting eggs at successive points along their length enabled Schnetter (1934b) to mark off 'potency regions' in the 12-hour blastoderm of the Honey Bee egg. Each of these regions when present in whole or in part guarantees the *complete formation* of the corresponding embryonic systems (*cf.* 'harmonic equipotential regions,' *e.g.*, limb-field in amphibia). Thus regu-

lation in the Honey Bee egg is, in general, 'stepwise,' a given region developing as a whole or not at all. In fig. 2a it can be seen that all the potency regions lie within or extend into the region of the differentiation center. Accordingly it may be regarded as a "concentration center" for potencies enabling whole-formation of the various organ regions. Fig. 2b shows that there is a shift of these potency regions during the time between the 12- and 24-hour blastoderm. This, with a few preliminary experiments on an intermediate stage, indicates that there is a gradual shifting of these boundaries out of the differentiation center and into their definitive position. These facts suggest that the differentiation center bears a causal relation to the development of the embryonic regions. The fact that a fixed (morphological) region of the bee egg may have a prospective potency in an early stage that is entirely different from (not merely more extensive than) its prospective significance as shown in a later stage, indicates that chemo-differentiation is not only progressively increasing as development proceeds but that there is also occurring a *redistribution* of the chemo-differentiated materials. Further a shift in the region of first visible differentiation in developing dwarfs following constrictions in the 12-hour stage (as evidenced by the more posterior position of the beginning of the mesodermal furrows) indicates that this point assumes about the same relative position in the decreased whole as in a normal egg. So presumably dynamic factors are of fundamental importance in the egg of the Honey Bee as well as *Platycnemis*.

In the ant *Camponotus* Reith (1931b) noticed that defects resulting from late cauterization of the presumptive anlage-region suggested a dependence of the posterior regions upon the anterior for normal differentiation. He reports two cases in which defects at the anterior end of the germ band resulted in the absence of differentiation although the nuclei migrated normally. Presumably these represent an elimination of the differentiation center.

In the beetle *Sitona* Reith (1935) reports admittedly incomplete experiments indicating the presence of a differentiation center located in the central region of the egg. This center seems to be stimulated by the activation center since no development occurs when the latter is destroyed during cleavage. He says that by

analogy with *Platycnemis* and the Honey Bee this center must be assigned a "regulative" significance.

In the higher Diptera the data from cauterization, constriction and centrifugation (Reith 1925, Pauli 1927, Rostand 1927, Strasburger 1934) show that in all cases mosaic or partial embryos are produced by elimination of any egg part irrespective of the age of the embryo. A physiological differentiation center affecting larval organization is not demonstrable although Henshaw's data (1934) indicate that there is some physiological regulator of early embryonic differentiation in *Drosophila* since only weak doses of x-rays were required to block development before gastrulation but much stronger doses were required later. Also, Geigy reports (1931b) that in the production of defective adults of *Drosophila* by ultra-violet irradiation of eggs, both the sensitization and desensitization to the rays begins in the thorax and proceeds posteriorly as a function of age. This is seemingly to be interpreted as a differentiation center in the presumptive adult thorax, the effect of which passes progressively posteriorly, even though no such center has been demonstrated for larval organization.

C. Interaction of Centers and Other Regions of the Egg

Seidel (1934) has shown that in *Platycnemis* an interaction between the cleavage nuclei and the region called the activation center results in a product which diffuses forward in the egg (see Fig. 1 a–b). As this product passes anteriorly there is a visible change in the structure of the yolk proceding space with the diffusion. However, this product does not directly affect differentiation; it functions by the activation of the differentiation center. The latter, in turn, appears to induce the onset of heterochronous cell divisions and the contraction of the yolk system which brings about the aggregation of cells to form the germ band and the later shift in the position of the same.

Comparison of the reactions of the activation center and differentiation center of *Platycnemis* under similar restrictions indicates that they differ in mode of action. A loose or temporary constriction in the region of the activation center results in no abnormality but only delay. But a loose or temporary constriction in the region of the differentiation center (after functioning

of the activation center) invariably results in an abnormal embryo. This is elucidated by proof that the first functions by the production and diffusion of a specific material substance, the second by dynamic movement processes which must have some as yet unknown physico-chemical basis.

The realization of the importance of dynamic phenomena in development has enabled further analysis of the processes underlying determination and regulation and of the significance of the 'centers.' Such an analysis, based primarily on his findings in *Platycnemis*, has been begun by Seidel (1934). The predominant notes in his discussion are the importance of the entire egg as a substrate for dynamic processes in determination, the subordination of the so-called 'centers' to the system as a whole, and the alternation of dynamic processes and "material reactions" during development. The latter is quite evident in the sequence of events in *Platycnemis*, viz., the migration of cleavage nuclei, the reaction between nuclear and cytoplasmic factors in the activation center, the diffusion of the reaction products cephalad from the activation center, reaction with the yolk system, and the contraction of the yolk system originating in the region of the differentiation center. The determination process is carried out by this alternating series of dynamic processes and material reactions, the former involving the egg system as a whole and enabling the reactions of more or less delimited substances and structures, the centers, to take place. In this light, regulation is not dependent upon the powers of definite centers but upon dynamic processes or structures made possible through such processes. It follows that regulative ability is limited by the degree of rigidity of the arrangement of all the substances and structures necessary for development. Regulation can occur only in that part of the egg in which normal dynamic processes can transpire, and the degree of regulation depends upon the extent to which they can proceed unhampered. As Seidel says, the entire egg must be regarded as a system in which not only the embryonic tissues and included factors but also the extra-embryonic parts must be held responsible for the determination of the organ-regions.

In no other group is there a set of data for any one species sufficiently extensive to permit such a complete analysis of factor

interaction. Reith (1931, 1932, 1935) shows an activation center at the posterior end of the egg of the ant and weevil. The action of its product is similar to that in the damsel fly but the onset of its action is not dependent on the entrance of cleavage nuclei into the region but is initiated presumably by some part or product of fertilization. However, in the beetle *Bruchus* Brauer & Taylor (1934) give a brief report indicating that the cleavage nuclei are necessary for the action of the activation center. Schnetter (1934b) was unable to demonstrate an activation center in the Honey Bee egg but he has shown the presence of a differentiation center which seems to bear a causal relation to the development of the embryonic rudiment. These data, while differing in certain details from the damsel fly, indicate that dynamic factors are responsible for the arrangement of the structural elements, since regulation involves a shift in the site of initial differentiation along with that of the potency regions. The more rigid the system, the less the regulative power—a principle which may involve the viscosity of the cytoplasm as suggested by the results of centrifuging the eggs of other insects (Section VI). In these insects, also, determination is probably brought about by a harmonious series of interacting processes.

In the determinate type of egg (Reith 1925, Pauli 1927, Sturtevant 1929) we must assume that the determination attained by such series of events is in large measure completed by the time of fertilization so that the various egg regions are 'self-differentiating.'

D. Comparison of Insects and Amphibia

In drawing a general comparison between insect and amphibian development, Seidel (1934) regards both the insectan differentiation center and the amphibian organizer as "factor regions," of which the ability to function is subordinate to the dynamic processes of the entire egg. In both, regulation is effected not through the developmental centers but through the system as a whole which the centers subserve. Fundamentally the determination processes in the two groups may be similar, but he adds that more detailed comparison must await further analysis of the causal relation of the insectan differentiation center to organ for-

mation. Evidence from the Honey Bee (Schnetter 1934b) indicates a similarity between the differentiation center and the organizer, in that the former is a concentration center for potencies enabling regional differentiation along the entire length of the egg, and the latter seems also to possess individuation factors.

Seidel also compares the action of the insectan activation center with the action of the inducing substance of the amphibian organizer. In *Platycnemis*, after the cleavage nuclei migrate into and react with the activation center, a substance diffuses forward through the yolk. In Amphibia, the organizer region (chordamesoderm) is carried under the ectoderm by the process of gastrulation, and the inducing substance reaches the overlying layer by direct contact. Interaction in the sense of an underlying layer influencing an overlying layer has not been demonstrated in insects.[8] In both insects and amphibia dynamic processes are instrumental in bringing the inducing substance to its field of action where it is the precursor of further dynamic processes—contraction of the yolk system in the one case, formation of the medullary tube in the other.

We have omitted two points from Seidel's comparison. First, his statement that any purely chemical hypothesis of the primary action of the differentiation center is improbable. This is based on the observation that aggregation to form the germ band depends on a contraction wave in the yolk system, and any constriction which interferes with this contraction results in an abnormal embryo. The nature of the origin of this contraction wave is unknown, and in the light of recent work on the chemical nature of the amphibian organizer it seems advisable to leave this question open, though, as Weiss (1935) points out, the 'chemical organizer' is really only an activator, not an organizer. Second, Seidel says that the principal difference between the amphibian organizer and the insectan differentiation center is that the former lays down a dorsal anlage, the latter a ventral anlage. We wonder if this is not as fundamental a similarity as difference since, in both, the embryo forms on that side of the egg which will give rise to the nervous system.

[8] Although metamerism is usually first evident in the mesoderm, there are several cases reported (*e.g.*, *Pieris*, Eastham, 1927) in which it is visible in the ectoderm before in the mesoderm.

Aside from Seidel's discussion, it may be noted that the activation center of the insect egg is similar to the amphibian organizer in (1) its location, (2) its activation in some species by fertilization or some concurrent phenomenon (*e. g. Camponotus*) although in certain species (*e. g. Platycnemis*) the cleavage nuclei are necessary for its functioning, (3) its functioning by the production of a specific substance, and (4) this substance in turn activating or establishing a second center (the differentiation center) which then directs development by dynamic phenomena. There is a paucity of data regarding causal relationships of the developmental centers to organ formation but this is also Seidel's principal reason for refraining from a definite analogy af the insectan differentiation center with the amphibian organizer.[9] The comparison leads inevitably to the question as to whether the differentiation center is to be considered a primary developmental center which is merely activated by the product of the activation center, or a secondary center produced by the activation center or by factors involving the egg as a whole. Seidel favors the former interpretation, but from the available data it seems that the latter is possible. Some of the observed effects of reducing the yolk system by partially constricting the egg of *Platycnemis* could also be explained by postulating that there is a certain minimum size to which the system can be reduced before it becomes incapable of producing the contraction wave leading to germband formation. Tying off the original locus of the differentiation center may be simply reducing the system so much that the forces concerned cannot bring about the simulation of the normal visible processes. In this light the differentiation center would be a focal point of forces—an effect, rather than a fixed region of causal factors. However, the production of partial embryos by complete constriction is possible evidence that the differentiation center may be a fixed region of potency factors. It seems that the exact nature of the differentiation center can be decided only by experiments analogous to the extirpation and explantation of organizer material in Amphibia. In this connection Weiss (1935) makes the illuminating suggestion that the activating and

[9] The only insect in which any causal relationship of the differentiation center to organ formation is known (Honey Bee) is one in which we know nothing about the activation center.

organizing functions which are combined in normal amphibian development, are spatially separated into two centers, the activation center and the differentiation center, in normal insect development.

VIII. BLASTOKINESIS OR MOVEMENTS OF THE EMBRYO

Prior to the differentiation of striated muscle fibers the insect embryo frequently undergoes extensive movements. These movements vary greatly in different insect groups (see Imms 1934 or Snodgrass 1935). They have been experimentally studied in the grasshopper *Melanoplus*. Here blastokinesis consists of a reversing of the longitudinal axis followed by a revolution around this axis. Slifer (1932a) shows that this change of position is accomplished by vigorous movements of the embryo itself. These movements originate as contraction waves running along the lateral borders of the dorsally-incomplete abdomen and passing rapidly to the head. With the closure of the dorsal wall and the formation of the dorsal vessel they seem to become resolved into the heart beat as was suggested by Nelsen (1931). In overwintering eggs, diapause interrupts incipient blastokinesis as well as an other developmental activities, these processes being resumed immediately after the end of the diapause period (diapause will be treated in Part II).

Although the embryonic membranes are usually ruptured Slifer reports one positive case in which blastokinesis was initiated and partly completed without the rupture of the serosa, showing that the contraction of the embryonic membranes cannot be the primary cause of revolution. Hence, in the grasshopper, the revolution of the embryo must be due to its own movements. In sections of embryos of this age she (1934) found unicellular, non-striated, spindle-shaped fibers in the position of the future abdominal muscles. She suggests that these cause the movements (striated muscles do not appear until nine days later).

Concerning the necessity of revolution Slifer (1932a) reports four cases in which it failed to occur and yet the embryos developed more or less normally but were incapable of hatching. But Tirelli (1931) reports that the occasional failure of blastokinesis

in the Silk Worm egg invariably results in death. However, in the latter case blastokinesis brings the dorsal surface of the embryo into a spatially and mechanically more favorable position whereas no apparent advantage is attained in the grasshopper. In *Platycnemis* Seidel (1929b) reports that prevention of blastokinesis by constriction seemingly inhibits development of a posterior part embryo beyond the differentiation of the organ systems, while if the anterior part of the embryo develops in front of an incomplete constriction, blastokinesis occurs in that part of the egg and histological differentiation is completed. Accordingly it seems that blastokinesis is prerequisite for the completion of development in *Platycnemis*.

Although not usually classed under blastokinesis we include here the report of Child & Howland (1933) that the migratiion of the germ cells of *Drosophila* from the posterior pole of the egg to the dorsal surface and thence to the interior of the embryo seems due to the force exerted by the rapid upward growth of the ventral blastoderm. They add that the subject needs further study.

IX. THE ANLAGEN PLAN OF THE EMBRYO

The only satisfactory worked-out anlagen plan of any indeterminate or incompletely determinate type of insect egg is that given by Seidel (1935) for *Platycnemis*. This is well shown in Fig. 3 which gives the blastoderm plan from all three views, and in Fig. 4 which shows the changes undergone during the formation of the embryo. The first phase of shortening of the embryo occurs simultaneously with the onset of action of the differentiation center (Fig. 4 a–b). During this time the presumptive head and abdominal regions contract while the thoracic region increases in length as a result of two movement-tendencies, one drawing the materials towards the region of the differentiation center (between the gnathal and thoracic anlagen), the other drawing the entire presumptive embryo towards the posterior end of the egg. The two tendencies coincide in front of the differentiation center but are opposed posterior to it. In the second phase of shortening (Fig. 4 b–c) the head and gnathal anlagen expand while the thorax and abdomen shorten. During this

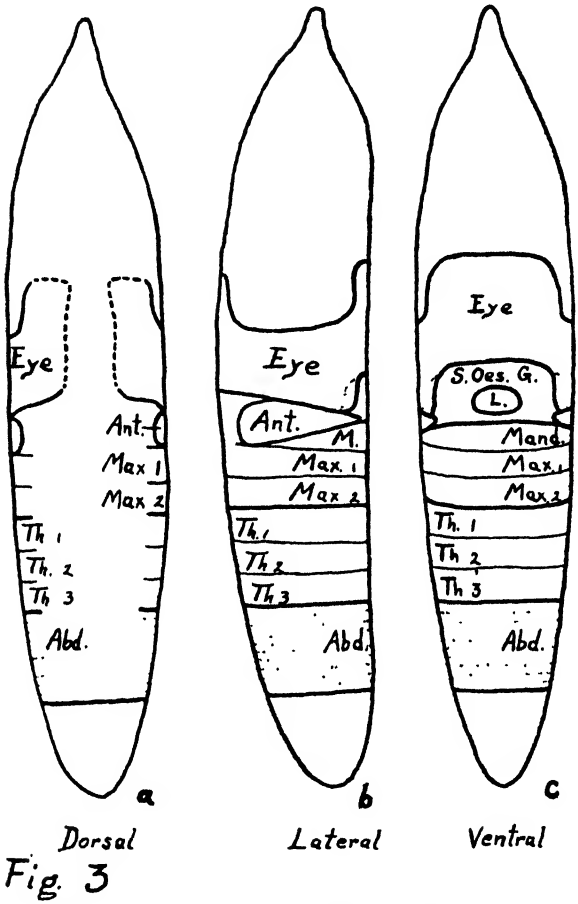

Fig. 3

Figure 3. Plan of the presumptive organ anlagen for the blastoderm stage. *a* dorsal side of egg, *b* left side, *c* ventral side. The numbers indicate the divisions of the egg (1 division equals 24 μ). *Abd* abdomen anlage, *Ant* antenna anlage, *Eye* Eye anlage, *L* labrum anlage, *Mand* mandible anlage, *Max 1–2* maxillae anlagen, *Th 1–3* thoracic segment anlagen, *S.Oes.G.* Supraoesophageal ganglion anlage. (After Seidel, 1935.)

phase the action of the differentiation center is no longer apparent. The entire embryo continues to move posteriorly and soon invaginates into the yolk. During and immediately following invagination the parts of the embryo elongate and assume larval proportions.

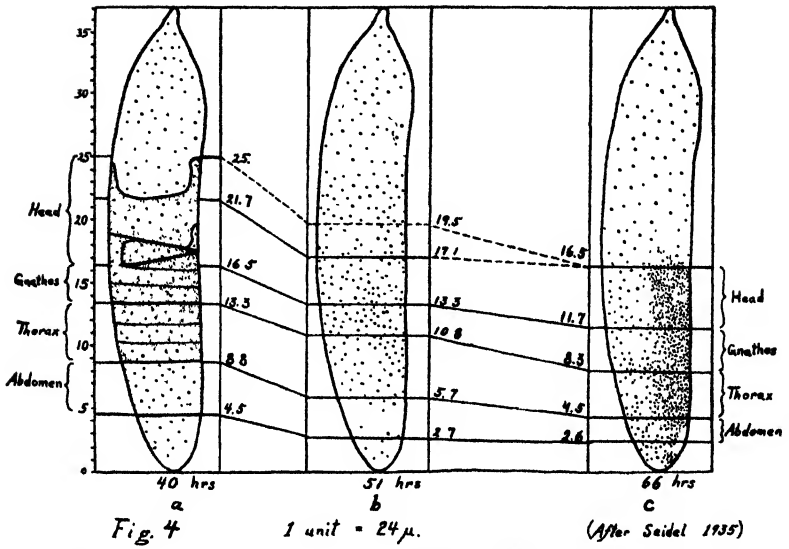

Figure 4. Graphic representation of the shifting of the anlage regions of the left side of the egg in reference to the movement of cell-nuclei. *a* Blastoderm stage through *b*, cell aggregation to form the germ band, to *c*, the completed embryo anlage. Abscissa: Time in hours after the 2-nuclei stage. Ordinate: Number of divisions from the posterior pole of the egg (1 division equals 24 μ). (After Seidel, 1935.)

From Seidel's detailed discussion of irradiation defects as marks in making these maps we note the following: (1) The study is hindered by regulation processes. (2) Raising the temperature accelerates the differentiation process more than the healing process and so aids the formation of defects. (3) For certain organs the experiments show a 'defect correlation' rather than a 'developmental correlation.' For instance there is a high correlation of eye and thoracic defects which Seidel suggests may be due to a primary defect changing yolk contraction and thereby altering the molding of the embryonic anlage. (4) Defect experiments do not show the true morphological course of development owing to the indirectness of physiological investigation; more truly they indicate a plan of the various factor regions.

Schnetter (1934b) gives a partial segmental map of the 12- and 24-hour blastoderm of the Honey Bee egg (Fig. 2) showing

a shift in the prospective significance of the parts of the blastoderm between these two stages. Incidentally he says that after the formation of the germ band the differentiation center no longer belongs to the structure of the whole egg but only to the embryo. With the shift of the presumptive embryonic parts the middle of the differentiation center shifts from division 24 of the egg to division 28.

For the determinate (mosaic) egg of the Diptera Reith (1925) and Pauli (1927) show that the parts of the embryo originate as presumptive anlagen at the same points where they later make their appearance, and that little or no regulation occurs. Sonnenblick (1934) and Howland & Child (1935) report that normal larvæ and adults may develop from punctured *Drosophila* eggs from which a portion of the contents has been extruded. Due to doubt as to the exact nature of this extruded material it is not possible to evaluate these results. However, Sturtevant (1929) shows by genetic analysis of *Drosophila* gynandromorphs that the presumptive imaginal discs must occupy the same relative positions in the blastoderm as the points where they later make their appearance in the larva. As healing processes are not involved in this case it seems that a shift in prospective significances such as Schnetter describes for the Honey Bee does not occur in *Drosophila*.

X. ORGAN FORMATION

1. **Endoderm**: There are no really pertinent experimental data. The midgut is clearly not the primitive archenteron. It is formed, practically regenerated, later in development from rudiments. Eastham (1927) and Snodgrass (1935) review the subject from a comparative-morphological standpoint. The principal difficulty arises from the fact that in some insects the lining of the midgut arises from mesenteron rudiments carried in on the tips of the stomodæal and proctodæal invaginations, whereas in other insects this lining is produced by proliferation from the tips of *unilaminar* stomodæal and proctodæal invaginations. Eastman (1927) and Richards (1932) have suggested that this is only a difference in the time of determination of the functional endoderm. Using maps of prospective significance Richards illus-

trates the difficulty encountered if we consider the functional endoderm as determined before its growth into the definitive midgut in forms in which it arises by proliferation from the unilaminar tips of the stomodæal and proctodæal investigations. He suggests that in such forms it is not determined before this time and that its determination must be a function of the position of the cells concerned.

Reith (1925) reports that the midgut anlagen are practically the only part of the House Fly egg capable of development beyond their prospective significance. In this species more than half of the midgut is formed from one end when either the stomodæal or proctodæal invagination is absent.

2. **Germ Cells**: In certain insects (Honey Bee, moths, etc.) the gonads and presumably also the germ cells originate in the genital ridge of the splanchnic mesoderm. This type has not been studied experimentally during embryonic stages. In certain other insects the germ cells are segregated at the posterior pole of the egg during cleavage (called 'pole cells'). Their further development is more or less independent of the rest of the embryo.

Hegner (1908, 1911) showed that the elimination of the posterior pole from the eggs of Chrysomelid beetles either by pricking and allowing part of the egg contents to flow out or by killing with a hot needle results in an embryo lacking germ cells and possessing certain structural defects. Reith (1925) obtained similar results with the House Fly. Geigy (1931a) reports that killing the posterior pole of *Drosophila* eggs by ultra-violet irradiation during cleavage results in adults whose gonads are composed of only mesodermal elements (*i.e.*, contain no germ cells). Shorter irradiation frequently resulted in unilateral castration. The single gonad might be small, of normal size or larger than normal. To explain these large single gonads he accepts Ruppert's suggestion (1924) that in addition to killing some of the cells the ultra-violet rays cause an adhesiveness of the germ cells so that they stick together during migration into the embryo instead of separating into two gonadal groups. More exacting data on *Drosophila* are given by Howland & Robertson (1934). They dechorionated eggs and killed part or all of the 'pole cells' by carefully localized point cauterization. The sole effect was

partial or total sterility. Therefore the 'pole cells' are not only destined to form the definitive germ cells but they are incapable of being regenerated by an otherwise normal embryo.

3. **Imaginal Discs**: This topic will be treated more fully in Part II. By analysis of *Drosophila* gynandromorphs Sturtevant (1929) shows that the cortical layer is not only determined for the parts of the embryo but also (perhaps secondarily) mapped out for the adult *via* the presumptive imaginal discs. Geigy's results (1931b) made it seem that Sturtevant's data were valid only for prospective significances since Geigy obtained imaginal defects only when he irradiated eggs with ultra-violet light after the differentiation of the larval organs had begun. Geigy therefore advanced the idea of two separate determination periods in Diptera, the first for the embryo, the second for the adult. But Smith (1935) reports similar non-hereditary defects from x-rayed female gametes, and thereby leads to our questioning the validity of Geigy's two periods. Perhaps the discrepancy can be traced to the different types of irradiation used but it seems best to leave it an open question.

4. **Duplication of single organs**: These are produced by the same agents that cause duplications of whole parts. They illustrate two points of interest: (1) that any internal organ, including the nervous system, or any external part is capable of duplication separately or in combination with other parts: and (2) that duplications represent a positive new or additional formation in the sense that the sum of the two duplicated parts exceeds the size of a single normal organ. In fact, the size is increased even when the parts 'heal' so that no duplications occur. To date duplications have been produced only in indeterminate types of eggs and the phenomenon is one of the criteria used to distinguish this type of development (Seidel, Krause).

Cappe de Baillon (1927) and von Lengerken (1928) suggest that some duplications may result from the fusion of two oöcytes whose cortical layers are partially determined at the time of fusion. Positive evidence of this is available only in the phasmids (indeterminate type of egg).

5. **Order of embryonic determination**: In addition to the determination process passing anteriorly and posteriorly from

the thoracic differentiation center there is sometimes a later, secondary determination for specific organ characteristics. The data are from intermediates.

To explain intersexes of the Gypsy Moth Goldschmidt (1927, 1931) postulates that the individuals begin development as one sex, that a physiological change constituting a turning point occurs, and that subsequent development is characteristic of the other sex. All structures finally determined before the time of this change will be of the former sex, all determined later will be of the opposite sex. An intersex is then a 'time mosaic' of male and female parts due to differences in the time of determination of specific organ-types (Shull 1930b). In application it is assumed that in the induced change from one sex to the other the order of determination is the reverse of the order of modification in specimens successively more like the opposite sex. Applying this Goldschmidt finds that the sex of the gonads and abdomen are determined before that of the wings and antennæ. One of the most interesting points is that the onset of histological differentiation of the sexual characters does not necessarily signify that the sex of those organs is finally determined. This is clearly shown by the gonads. These may develop to the point of containing almost mature eggs or sperm and then following sex-reversal have the differentiated germ cells degenerate and be replaced by the differentiation of germ cells of the opposite sex. All this occurs because of the genetic constitution of the cells themselves and presumably is not influenced by hormones.

Shull (1930b, 1931) reports that when the offspring of winged females of the aphid *Macrosiphum* are gradually changed from gamic to parthenogenetic type, the differential features of successive offspring change at different times and rates. The first to change are the color of the antennæ and the color and size of the tibial sensoria, then the body color and reproductive system. Within the reproductive system the collateral glands and seminal receptacles change sooner than the ovarioles. However, when the mother is induced to revert to the production of gamic instead of parthenogenetic offspring, this series of changes instead of occurring in the same order occurs in the reverse order contrary to expectations based upon the time of determination hypothesis. This phenomenon remains unexplained.

XI. SUMMARY

1. The earlier developmental processes in the insect egg have been experimentally studied in species of Orthoptera, Odonata, Coleoptera, Hymenoptera and Diptera. (Section II.)

2. The fundamental processes underlying the determination of polarity and symmetry are unknown. In bilaterally symmetrical eggs, at least, where the main axes are usually coincident with those of the mother, polarity and symmetry must be impressed upon the developing oöcyte, perhaps by extra-oval factors. Secondary influence by the sperm, if any, would be possible only in radially symmetrical eggs. Gravity is not a factor. (Section III.)

3. The phenomena of fertilization are likewise poorly understood. At fertilization eggs are usually in the first meiotic metaphase. In some species the sperm does, in others does not have an activating function. Polyspermy is common. Bi- and trinucleate eggs may develop with correlated effects on the morphology and genetic constitution of the products. Parthenogenesis is widespread and has been induced in some gamic species. (Section IV.)

4. The cleavage nuclei are not restricted as to their destination in the embryo. They divide synchronously for a specific number of divisions but sooner or later heterochronism sets in. They are not the decisive factors in determination and are indeterminate or totipotent at least until the blastoderm stage (except in certain species in which the nuclei entering the germ-tract determinant region are differentiated sooner, and also the vitellophags of certain species). (Section V–A.)

Migration of cleavage nuclei is generally regarded as not autonomous but the result of extrinsic factors in the surrounding egg plasma (flowing or contraction) which are also instrumental in the formation of the inner cortical layer. The origin of these movements is at present a matter of conjecture. (Section V–B.)

Nuclear migration is distinct from blastoderm-cell formation. There is evidence that the latter may be a function of the activation center, predetermined cytoplasm, oöplasmic streaming or nuclear stimulation, these factors varying in importance in different insects. (Section V–C.)

5. Insect eggs may be arranged in a series ranging from indeterminate to determinate types. This series is valid in regard to both the relative time of visible differentiation of the organ anlagen (the sooner visible the more determinate the egg) and the degree of potency or regulative power of the egg parts (greater regulation and later determination in indeterminate eggs). Hence at the time of deposition the egg may be of either the regulative or mosaic type, with subsequent determination in the former occurring either rapidly or gradually and sometimes accompanied by visible differentiation of the unsegmented cytoplasm (the ant). Cell formation probably plays only an indirect role in differentiation. (Section VI.)

6. Two physiological centers may be present in the insect egg: an activation center at the posterior pole and a differentiation center in the presumptive thoracic region. The former has been demonstrated in a damsel fly, two beetles and two ants; the latter is probably present in all insects and has been studied in detail in a damsel fly and bee.

The activation center confers upon the egg the ability to undergo development, but its rôle in embryonic determination is unknown. It is not morphologically distinct, may or may not require interaction with cleavage nuclei, and releases a substance which spreads anteriorly through the egg. This product seemingly stimulates the differentiation center to function. (Section VII–A.)

The differentiation center normally coincides with the region where differentiation of the embryonic rudiment begins in the presumptive thoracic region. Reduction of the size of the egg system results in a displacement of the region of first visible differentiation to a position relative to the new whole, but the physiological center is seemingly retained at its original site. This physiological center is essential for differentiation and, where analyzed, functions as a dynamic center whence proceed waves of contraction in the yolk system which control differentiation and regulation. In the bee it is a "concentration center of potencies." The embryonic differentiation center is also concerned in the development of adult structures in *Drosophila*. (Section VII–B.)

The entire egg must be regarded as a system in which not only the embryonic part and its included factors but also the extra-embryonic parts, especially the yolk system, are instrumental in determination, differentiation and regulation. Determination is carried out by a harmonious alternating series of interacting dynamic processes (flowing and contraction) and material reactions, the former involving the egg system as a whole and enabling the reactions of more or less definite centers. Hence developmental processes are not primarily the result of the functioning of 'centers' but rather of the relations existing in the egg as a whole. (Section VII–C.)

On this basis a comparison can be drawn between insect and amphibian eggs, but at present the superficial resemblances scarcely allow direct analogy of the vertebrate organizer with either the insect activation center or differentiation center or both. (Section VII–D.)

7. Blastokinesis, at least in the grasshopper, is accomplished by vigorous movements of the embryo itself. (Section VIII.)

8. Maps have been made of the general embryonic anlagen-plan of the damsel fly (by defect experiments which show potencies rather than true promorphology) and of the potencies of the various levels of the Honey Bee egg (by constriction experiments). In the determinate eggs of Diptera presumptive anlagen arise at the points where the corresponding organs first become visible. (Section IX.)

9. There are only incidental experimental data on organ-formation, the mosaic stage of differentiation having still to be analyzed in detail. Notes are given on the endoderm, germ cells, imaginal discs, organ duplications and order of embryonic determination. In certain insects in which some of the cleavage nuclei become segregated at an early stage at the posterior pole of the egg ('pole cells') it has been conclusively proved that these cells give rise to the definitive germ cells. (Section X.)

XII. LITERATURE

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THE GENOTYPES OF THE NORTH AMERICAN HADENINÆ (LEPIDOPTERA, NOCTUIDÆ)

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In the December 1933 issue of the JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY (pages 441–456), the writer published a list of the genotypes of the North American Hadeninæ. This list also stated when and by whom these types were designated. That article with some additions forms the basis for the present paper.

Probably no group of insects needs a more careful revision than the Noctuidæ (Phalænidæ). Such a task is not easy because so many species are involved. Many have tried to group these species into genera but few workers agree upon what constitutes a genus. This lack of harmony has led to confusion. Many specialists will accept a genus even though they may not be able to define it. Most of the recently erected genera have been well described and defined but the older ones need to be redescribed and their boundaries more clearly set. To properly define a genus, one should consider all morphological characters even if they seem to have no generic value. This may make the generic description rather lengthy but the information contained in such a description will be of great value to those who wish to make a critical comparison of related genera. The salient characters could be listed first—say in italics—so that it would be unnecessary to read through the entire description.

Where should one begin in forming generic concepts? The writer believes that the genotypes offer a good starting point. Having worked out their structure, we now have morphological "yardsticks" with which we can measure other species and see where they fit. It is true that no one species can show the range of variation within the genus but we may start with one species and group others about it. Having done this, we may turn back and elaborate upon our original generic concept. It is the aim of this article to describe these basic species in the North American

Hadeninæ so that others may supplement it with a morphological study of species other than genotypes.

SCOPE OF THE ARTICLE

This article includes the following—First—most of the Hadenine genera found in North America; Second—all genera considered synonymic with our genera; Third—a few purely exotic genera which have found their way in our lists from time to time. Some of the latter group have been considered synonymic with our genera and in a few cases our genera have been considered synonymic with them.

In the first group we have the following—Acerra Grt., Admetovis Grt., Anarta Ochs., Barathra Hub., Borolia Moore, Buchholzia Barnes and Benj. (Eubuchholzia B. and B.), Cardepia Hampson, Cea Grt., Ceramica Gn., Chabuata Walk., Copimamestra Grt., Craterestra Hamp., Discestra Hamp., Engelhardtia Barnes, Epia Hub., Eriopyga Gn., Eupsephopaectes Grt., Faronta Smith, Hadena Schrank, Heliophila Hub., Himella Grt., Hyperepia Barnes and Lind., Lasiestra Hamp., Lasionycta Auriv., Leucania Ochs., Lophoceramica Dyar, Mamestra Ochs., Miodera Smith, Morrisonia Grt., Neleucania Smith, Nephelodes Gn., Ommatostola Grt., Parameana Barnes and Benj., Perigonica Smith, Perigrapha Lederer, Pseudorthodes Morrison, Scotogramma Smith, Stretchia Hy. Edw., Trichoclea Grt., Trichocosmia Grt., Tricholita Grt., Trichopolia Grt., Ulolonche Smith, Ursogastra Smith, Xanthopastes Hub., Xylomania Hamp., Zosteropoda Grt.

In the second group: Synonym for Eriopyga-Hypotrix Gn., Synonyms for Hadena-Aethria Hub., Aplecta Gn., Astrapetis Hub., Crocigrapha Grt., Dargida Walk., Dianthoecia Bois., Diataraxia Hub., Neuria Gn. Incorrectly considered synonymic with Mamestra Aletia Hub., Alysia Gn., Charaeas Steph., Haderonia Staud., Hyphilare Hub., Hyssia Gn., Melanchra Hub., Meterana Butl., Synonymic with Nephelodes Monosca Walk., Monostola Alpher., Synonymic with Xanthopastes Philochrysa Grt. The exact status of all of these genera will be considered in the article.

In the third group Neuronia Hub. (Epineuronia Staud.), Eury-

psyche Butl., Ichneutica Mey., Magusa Walk., Meliana Curtis, Naesia Walk., Pastona Walk., Sideridis Hub., Xylomyges Gn.

DESCRIPTION AND DESIGNATION OF MORPHOLOGICAL CHARACTERISTICS

In this section each morphological character will be described and given a type number, *e. g.* frons type 1, male antennæ type 2, etc. Throughout the article these type numbers will be used in describing the genotypes—not because the writer prefers this method—but to save space and to reduce the cost of publication.

The Head

Vestiture.

Type 1—hair.

Type 2—hair and scales.

Type 3—scales.

Type 4—deeply cleft scales.

Compound Eyes.

Type 1—apparently naked.

Type 2—hair restricted to the posterior portion of the eye.

Type 3—uniformly clothed with hair.

Frons.

Type 1—rather uniformly rounded.

Type 2—tends to project forward and upward.

Type 3—tends to project forward and downward.

Type 4—protrudes forward, not rounded, front almost vertical.

Type 5—protrudes slightly forward and downward, with indications of a slight "T" shaped protuberance.

Type 6—rounded and full, front slightly excavated.

Type 7—uniformly rounded, ventral margin with a knob-like prominence.

Type 8—with an inverted heart shaped protuberance which is smooth on its frontal surface.

Type 9—with an inverted heart shaped protuberance that is roughened on its frontal surface.

Type 10—with a truncated conical corneous process.

Type 11—with a semi-lunate corneous prominence raised at its edges.

Type 12—extends forward and upward in the form of an inverted wedge which bears near its apex a smaller wedge-shaped prominence. Ventral margin with an upturned corneous ridge.

Type 13—protrudes forward and upward with the frontal surface convex.

Antennæ of the male.

Type 1—filiform, scaled above, ventral surface clothed with fine cilia to long hair, setæ may or may not be present. Antennæ round or oval in cross section, sometimes flattened on the ventral surface.

Type 2—filiform and similar to type 1 except that the antennæ are wedge-shaped in cross section.

Type 3—crenulated, scaled above, clothed with very long cilia beneath. Each segment bears a pair of very long lateral setæ.

Type 4—crenulated, scaled above, ventral surface of the crenulations bearing short cilia. At the tip of each crenulation there is a pencil of very long hair.

Type 5—crenulated and flattened, scaled above, ventral surface of the crenulations along their distal margins bear long hair. At the extremity of each crenulation there is a stiff seta which is more or less hidden by the hairy vestiture.

Type 6—crenulated, scaled above, bearing fine cilia beneath. At the tips of the crenulations are pencils of long hairs no lateral setae present.

Type 7—crenulated, dorsal surface scaled, ventral surface covered with short hair. Each crenulation bears at its tip a tuft of long hair and a setum.

Type 8—serrate, clothed above with scales and ventrally with a combination of fine cilia long hairs. The hairs are restricted to the distal portions of the segments.

Type 9—serrate, the serrations formed by wedged-shaped prominences on the ventral surface of the shaft. These prominences are clothed with long hair and a pair of lateral setæ. Dorsally the antenna is scaled.

Type 10—serrate, almost bipectinate, dorsal surface scaled, ventral surface covered with hair with longer bristles of hair on the tips of the serrations and on their mid-ventral surfaces. Serrations not of the same size on both sides of the antenna.

Type 11—bipectinate but not flattened, pectinations not of the same size on both sides of the shaft, even the longer ones quite short. At the end of each branch there is a rather prominent setum. The antenna is scaled above, finely ciliated beneath with the exception of the pectinations which are clothed beneath with long hair.

Type 12—flattened and bipectinate, pectinations not of the same size on both sides of the shaft. Dorsal surface scaled, ventral surface clothed with long hair. At the tips of each pectination there is a very prominent seta. Ventral surface of the shaft serrated.

Type 13—bipectinate, pectinations not of the same size on both sides of the shaft. Dorsal surface scaled, ventral surface clothed with long hair. Each pectination terminated with a prominent seta. Ventral surface of the shaft crenulated.

Type 14—bipectinate and serrate, pectinations longer on one side than the other. Antenna scaled above, ventral surface of the shaft and pectinations clothed with long hair. At the end of each pectination there is a rather stout seta.

Type 15—bipectinate, pectinations not of the same size on both sides of the shaft. Dorsal surface of the antenna scaled, ventral surface of the shaft and pectinations clothed with long hair.

Type 16—bipectinate, pectinations not of the same size on both sides of the shaft. Segments very distinct on their dorsal surface which is clothed with scales. Ventral surface of the shaft and the pectinations clothed with very long hair. Hair at the tips of the pectinations a trifle longer.

Type 17—bipectinate, pectinations not of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with moderately long hair.

Type 18—bipectinate, the pectinations not of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and pectinations clothed with long hair. At the tips of each pectination there are three prominent setæ.

Type 19—bipectinate, pectinations not of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and of the pectinations clothed with short hair. At the tips of each pectination there are two or three short setae.

Type 20—bipectinate, pectinations equal on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with long hair. No setæ at the tips of the pectinations.

Type 21—bipectinate, pectinations almost the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with long hair. Each pectination bears at its tip a prominent seta.

Type 22—bipectinate, pectinations of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations covered with short hair. Each pectination bears at its tip a prominent seta.

Type 23—bipectinate, pectinations of the same size on both sides of the shaft. Antenna scaled above, ventral surface of the shaft and the pectinations clothed with long hair. Each pectination bears at its tip two or three prominent setae. Shaft serrate ventrally.

Type 24—bipectinate, pectinations of the same size on both sides of the shaft. Antenna scaled dorsally, ventral surface of the shaft and the pectinations covered with short hair. Each pectination bears at its tip several prominent setæ.

Antennæ of female.

Type 1—filiform, scaled above, vestiture of the under side varies from long hair to fine cilia. Setæ may or may not be present. Antennæ oval or round in cross section.

Type 2—filiform, scaled above, vestiture beneath varies from long hair to fine cilia. Setæ may or may not be present. Antennæ wedge shaped in cross section.

Type 3—serrate when viewed from the side, ventrally each segment is heart-shaped, the upper lobes bearing several prominent setæ. Dorsally scaled, ventral surface covered with fine cilia.

Type 4—crenulated, scaled above, finely ciliated beneath. Each segment bears at least one pair of long setæ near its distal extremity.

Type 5—serrate, dorsally scaled, ventrally clothed with moderately long hair. Each segment bears a pair of prominent setæ.

Type 6—serrate and flattened. Dorsally scaled, ventral surface covered with long hair. Each segment bears a pair of lateral setæ.

Type 7—serrate, the serrations not of the same size on both sides of the shaft. Dorsal surface clothed with scales, ventrally covered with fine hair. Each segment bears a pair of very long lateral setæ.

Type 8—bipectinate, pectinations short and of the same size on both sides of the shaft. Dorsally scaled, ventral surface of the shaft and the pectinations clothed with long hair. Each pectination bears at its tip a prominent seta.

Type 9—bipectinate, pectinations long and of the same size on both sides of the shaft. Dorsally scaled, ventral surface of the shaft and the pectinations covered with short hair. Each pectination bears at its tip a prominent seta.

Vestiture of the palpi.

Type 1—all segments compactly scaled.

Type 2—all segments scaled.

Type 3—proximal segment bearing a mixture of hair and scales, all other segments scaled.

Type 4—proximal and middle segments bears a mixture of hair and scales, distal scaled.

Type 5—all segments bearing a mixture of hair and scales.

Ratio of the palpal segments.

Type	Distal	Middle
1	1.0	.75–1.9
2	1.0	2.00–2.90
3	1.0	3.00–3.90

Proboscis.

Type 1—fully developed.

Type 2—poorly developed or weak.

The Thorax

Vestiture of the thorax.

Type 1—hair.

Type 2—hair and scales.

Type 3—scales.

Crests.

Type 1—none.

Type 2—a prothoracic crest present; others, if present, indistinct.

Type 3—indistinct pro- and meta-thoracic crests.

Type 4—indications of meta-thoracic crest.

Type 5—a divided pro- and a distinct meta-thoracic crest.

Type 6—a divided pro-, a meso-, and a meta-thoracic crest.

Costal margin of the primaries.

Type 1—straight.

Type 2—straight but lobed at the base.

Type 3—slightly convex.

Type 4—concave.

Apex of the primaries.

Type 1—truncated.

Type 2—rounded.

Type 3—drawn downward, sometimes to a point

Type 4—pointed.

Outer margin of the primaries.

Type 1—straight to very obliquely incurved.

Type 2—slightly convex.

Type 3—rounded outwardly at the tips of veins M_2 and M_3, very oblique to anal margin.

Type 4—rounded outwardly at the tips of veins M_3 and Cu_1, very oblique to anal margin.

Type 5—excavated to the middle where it forms a distinct angulation.

Sc and R of the secondaries.

Type 1—Sc and R confluent at their bases.

Type 2—Sc and R touching near the base of the wing, then diverging.

Vestiture of the fore-leg.

Type 1—femur of the fore-leg fringed with coarse hair beneath, remainder of the leg scaled.

Type 2—leg scaled throughout, not fringed with hair.

Structure of the fore-leg.

Type 1—typical in structure, *i.e.*, with only the usual spines present. (See Fig. 268.)

Type 2—fore-tibia with a curved claw on the outer side.

Type 3—a large curved spine near the distal end of the first tarsal segment, all spines on the first and second tarsal segment overdeveloped.

Type 4—one or two curved claws on the anterior face of the fore-tibia, also a large curved spine at the distal extremity of the first tarsal segment.

Type 5—the distal portion of the tibia bearing several large spurs on the anterior and posterior faces.

Type 6—tibiæ with several short spines.

Type 7—with at least three very large spines on the outer side of the first tarsal segment, on the succeeding two segments the spines are overdeveloped on the outer side.

Vestiture of the middle leg.

Type 1—scaled, ventral edge of the femur and dorsal margin of the tibiæ fringed with coarse hair and long scales.

Type 2—scaled throughout, not fringed with hair.

Structure of the middle leg.

Type 1—typical in structure, *i.e.*, with only the usual spines on the tarsi and the two spurs on the tibia. (See Fig. 269.)

Type 2—tibiæ with several short spines rather evenly distributed.

Vestiture of the hind leg.

Type 1—as type 1 of the middle leg.

Type 2—as type 2 of the middle leg.

Structure of the hind leg.

Type 1—typical in structure, *i.e.*, with only the usual spines on the tarsi and four spines on the tibia. (See Fig. 270.)

Type 2—as type 2 of the middle leg.

The Abdomen

Vestiture of the abdomen.

Type 1—hair dorsally and ventrally.

Type 2—dorsally hair, ventrally mixed hair and scales.

Type 3—dorsally hair, ventrally scaled.

Type 4—dorsally mixture of hair and scales, ventrally mostly scales.

Type 5—dorsally mixture of hair and scales, ventrally hair.

Type 6—dorsally and ventrally mixture of hair and scales.

Type 7—dorsally and ventrally scaled.

Dorsal abdominal crests.

Type 1—none.

Type 2—poorly defined.

Type 3—one on the first segment.

Type 4—a crest on the first and second segments.

Type 5—a crest on the first, indications of crests on the second and third.

Type 6—crests on the first, second, and third segments.

Type 7—a row of mid-dorsal crests.

Lateral abdominal crests.

Type 1—none present.

Type 2—crests indistinct.

Type 3—present and distinct.

KEY TO THE GENOTYPES

In making this key the writer has avoided, as far as possible, the use of such sexual characters as the structure of the male or female antennæ. To do this it was sometimes necessary to make distinctions on the basis of the vestiture of the head or thorax or even the presence or absence of thoracic and abdominal crests. The use of such characters in the key is merely for convenience and they are not to be considered of primary importance in generic classification.

It is hoped that this key can be used to classify the many North American species of Hadeninæ other than genotypes.

1. Eyes apparently naked, *i.e.*, clothed with very fine cilia 2
   Eyes clothed with short hair that is confined to the posterior portion 4
   Eyes clothed with hair that is uniformly distributed 6
2. Frons protrudes forward and upward with the frontal surface convex. *Parameana*
   Frons rather uniformly rounded although sometimes rather prominent 3
3. Legs rather compactly scaled, antenna of the male serrate *Ommatostola*
   Legs fringed with long hair and scales, antenna of male filiform. *Buchholzia*
4. Vestiture of the thorax a mixture of hair and scales 5
   Vestiture of the thorax scales . . . . . *Trichopolia*

5. Apex of the primaries truncated, antennæ of the male bipectinate, of the female filiform *Lophoceramica*
   Apex of the primaries rounded, antenna in both sexes bipectinate. *Tricholita*
   Apex of the primaries drawn downward, antenna of the male filiform. *Ursogastra*
6. Frons uniformly rounded, ventral margin with knob-like prominence. *Xanthopastes*
   Frons uniformly rounded, ventral margin without a knob 7
   Frons not uniformly rounded 24
7. Proboscis fully developed 8
   Proboscis poorly developed 22
8. Costal margin of the primaries straight 9
   Costal margin of the primaries straight but lobed at the base. *Ulolonche*
   Costal margin of the primaries slightly convex 16
   Costal margin of the primaries slightly concave 20
9. Outer margin of the primaries straight to obliquely incurved 10
   Outer margin of primaries rounded outwardly at the tips of veins M_2 and M_3 very oblique to anal margin *Pastona*
   Outer margin of the primaries rounded outwardly at the tips of M_3 and Cu_1 very oblique to the anal margin *Hypotrix*
   Outer margin of the primaries excavated to the middle where it forms a distinct angulation *Perigonica*
10. Fore leg with only the usual spines 11
    Fore leg with at least three very large spines on the outer surface of the first tarsal segment, on the next two segments the spines on the outer side are overdeveloped *Admetovia*
11. Vestiture of the head hair only 12
    Vestiture of the head hair and scales or scales only 15
12. Vestiture of the thorax hair only 13
    Vestiture of the thorax hair and scales or scales only 14
13. Apex of the primaries drawn downward, vestiture of the abdomen hair and scales dorsally and ventrally *Acerra*
    Apex of the primaries truncated, dorsal surface of the abdomen covered with hair, ventral surface with hair and scales *Alysia*
14. No dorsal abdominal or thoracic crests *Heliophila*
    Thoracic and dorsal abdominal crests present *Chabuata*
15. (a) Antenna of the male filiform, oval or round in cross section. *Melanchra* group
    (b) Antenna of the male filiform, wedge-shaped in cross section. *Pseudorthodes* and *Hadena* group
    (c) Antenna of the male crenulated, ventral surface bears short cilia, pencils of long hairs at the tips of the crenulations *Xylomyges*
    (d) Antenna of the male crenulated and flattened, scaled above, ventral surface of the crenulations along their distal margins bearing

long hair, at the extremity of each crenulation there is a stiff seta *Morrisonia*

(e) Antenna of the male bipectinate, not flattened, pectinations not of equal size on opposite sides of the shaft and all quite short, ventral surface ciliated and at the end of each pectination there is a long setum *Nephelodes*

(f) Antenna of the male bipectinate, not flattened, pectinations not of equal size on opposite sides of the shaft, dorsal surface scaled, ventral surface clothed with long hair. Each pectination bears at its tip a prominent setum. Ventral surface of the shaft crenulated *Stretchia*

(g) Antenna of the male bipectinate and flattened, pectinations not of equal size on opposite sides of the shaft, ventral surface clothed with long hair. At the tip of each pectination there is a stout setum. Ventral surface of the shaft serrate *Hyperepia*

(h) Antenna of the male bipectinate and serrate but not flattened. The pectinations longer on one side of the shaft than the other. Antenna scaled above, ventral surface clothed with long hair. There is a stout setum at the tip of each pectination *Haderonia*

16. Vestiture of the legs compact scales *Meliana*
Vestiture of the legs hair and scales 17

17. Apex of the primaries drawn downward *Eriopyga*
Apex of the primaries truncated 18

18. Vestiture of the palpi scales only *Borolia*
Proximal and middle segments of the palpi bearing hair and scales, distal segment scaled 19

19. Antenna of the male filiform, middle segment of palpi more than twice the length of the distal *Naesia*
Antenna of the male crenulated, middle segment of the palpi not more than twice the length of the distal *Himella*

20. Apex of the primaries truncated *Anarta*
Apex of the primaries pointed 21

21. Palpi with the proximal segments clothed with hair and scales. *Zosteropoda*
Palpi with all segments compactly scaled *Nelcucania*

22. Outer margin of the primaries slightly convex *Charapas*
Outer margin of the primaries straight or obliquely incurved 23

23. Vestiture of the head and thorax hair *Monostola*
Vestiture of the head and thorax hair and scales or scales only. *Epineuronia*

24. Frons projects forward and upward 25
Frons projects forward and downward 32
Frons protrudes forward and downward with indications of a slight "T" shaped protuberance *Epia*
Frons rounded out, front slightly excavated *Ichneutica*

Frons with an inverted heart shaped protuberance which is smooth on its frontal surface *Trichoclea*
Frons with an inverted heart shaped protuberance which is roughened on its frontal surface *Miodera*
Frons extends forward and upward in the form of an inverted wedge which bears near its apex a prominence *Cea*
Frons with a truncated conical prominence *Craterestra*
Frons with a semi-lunate prominence with raised edges *Discestra*
25. Proboscis fully developed 26
Proboscis poorly developed 31
26. Costal margin of the primaries straight 27
Costal margin of the primaries straight but lobed at the base. *Lasiestra*
Costal margin of the primaries slightly convex *Eurypsyche*
27. Fore leg with only the usual spines 28
Fore leg with a curved claw on the outer side. *Mamestra* and *Copimamestra*
28. Legs compactly scaled *Trichocosmia*
Legs fringed with hair and scales 29
29. Antenna of the male bipectinate, of the female serrate *Xylomania*
Antennæ in both sexes filiform 30
30. No distinct thoracic crest *Cerdepia*
Distinct thoracic crest *Barathra* and *Scotogramma*
31. Apex of primaries truncated, thoracic crests present *Perigrapha*
Apex of primaries drawn down, no thoracic crests *Engelhardtia*
32. Outer margin of the primaries straight or very obliquely incurved, vestiture of the thorax hair *Sideridis*
Outer margin of the primaries slightly convex, vestiture of the thorax scales *Neuria*

The Hadeninæ

The Noctuidæ can be divided into two groups on the basis of the development of vein 5(M_2) of the hind wing. By far the greater number belong to the group in which this vein is well developed but in four subfamilies *i.e.*, Hadeninæ, Cucullianæ, Agrotinæ, and Acronyctinæ, vein 5 is obsolescent from the middle of the discocellulars. It can be seen from this that the Hadeninæ are closely related to three other subfamilies. Hampson gives the following key for the separation of the four subfamilies.

"A¹ Mid and hind tibiæ or hind tibiæ only spined Agrotinæ
B¹ Mid or hind tibiæ not spined.
A² Eyes hairy Hadeninæ
B² Eyes not hairy.
A³ Eyes overhung with cilia Cucullianæ
BB³ Eyes not overhung with cilia Acronyctinæ"

A more complete description of the Hadeninæ, taken from Hampson, is as follows: "Proboscis usually well developed, sometimes aborted; palpi usually short, upturned or porrect; frons often with rounded prominence with corneous plate below it, or with corneous processes of various forms; eyes hairy, sometimes overhung by long cilia; antennæ usually ciliated, often pectinated or serrate. Thorax clothed with hair and scales when there are usually crests on the pro- and meta thorax, or a ridge like dorsal crest, or clothed with hair only; tibiæ without spines, the fore tibia rarely with terminal spine, the proximal joints of the fore tarsi sometimes with curved claw-like spines, abdomen usually with series of dorsal crests or one crest at the base. Wings usually broad, the termen rounded or crenulate, rarely slightly angulated at the middle; fore wing with vein 1a weak, not anastomosing with 1b; 1_c absent; 2 from middle of cell; 3 and 5 from near lower angle; 6 from upper angle; 9 from 10 anastomosing with 8 to form the areole; in *Erana* with 7, 8, 9, stalked; 10 from cell. Hind wings with veins 1_a and 1_b present, 1c absent; 3 and 4 from lower angle of cell; 5 obsolescent from or from just below the middle of the discocellulars; 6, 7 from upper angle or shortly stalked; 8 arising free then bent down touching the cell then again diverging. In several genera the males often have secondary sexual tufts of hair or fans of scales on the thorax, legs or abdomen and in the genus *Eriopyga* patches of androconia on the wings of very diverse forms. In *Cirphis* the underside is sometimes clothed with slivery metallic scales."

Of the characteristics mentioned above, many of which are not peculiar to the Hadeninæ, the vestiture of the eyes and the spinosity of the tibiæ deserve further consideration.

In the typical Hadeninæ, the eyes are evenly clothed with hair which may be long or short. However, this characteristic is not constant for the entire subfamily for in three genera the eyes appeared to be naked (Dr. Barnes claims that hair is present but very fine and difficult to see) and in four other genera the hair is present but confined to the posterior portion of the eye.

As a rule the tibiæ of the Hadeninæ are not provided with spines the spinose condition being found chiefly in the Agrotinæ. However one genus whose hairy eyes place it in the Hadeninæ, shows developed spines or claws on the tibiæ.

It would seem from what has been said concerning the vestiture of the eyes and the spinosity of the tibiæ, that there are several Hadenine genera which stand between the true Hadeninæ and its allied subfamilies. This fact has some bearing upon the arrangement of the genera in this article. Since the members of the related subfamilies have naked eyes, the writer assumes that the stock from which the Hadeninæ arose also had naked eyes. This idea seems to be supported by the fact that in three genera the cilia upon the eyes are so fine that the eyes appear to be naked. In four other genera the eyes are only partly clothed with hair.

The spinosity of the fore tibia is also an unusual character among the Hadeninæ and may indicate relationship to the Agrotinæ. If the Agrotinæ and Hadeninæ are closely related, say through a common ancestor, then the one Hadenine genus in which the fore tibia is spined should be considered first. This is the reason for placing *Mamestra (Copimamestra)* first. This genus has, however, taken on the Hadenine character of hairy eyes. Another line of development is indicated by *Buchholzia, Ommatostola*, and *Parameana* in which the spinose condition of the fore tibia is lost but the eyes are almost naked and the writer believes that in some specimens they are naked. These three genera must also be considered as standing close to the base of the Hadenine stem and for this reason they form the second group to be considered. The Buchholzia group seem to lead into forms in which the eyes are partly clothed with hair so this group is followed by *Ursogastra, Lophoceramica, Tricholita,* and *Trichopolia* in which the hair is confined to the posterior part of the eye.

Next comes the bulk of the genera that are typical Hadenines having uniformly hairy eyes and no tibial spines or claws. There are many ways in which these could be divided but the writer has chosen to arrange them on the basis of wing form—those in which the outer margin is more or less even and those in which the outer margin is produced in the form of a lobe or angulated. The former section, normal wing form, can be further divided into two groups: (1) those with enlarged spines on the first tarsal segment, (2) those in which all tarsal spines are normal in their developement.

The genera are accordingly grouped in the following sequence.

Eyes uniformly hairy

Group 1—Fore tibia armed with a distinct claw—Mamestra (Copimamestra).

Tibiæ without claws

Group 2—Eyes naked or apparently so—Eubuchholzia, Parameana, and Ommatostola.

Group 3—Eyes partly clothed with hair—Ursogastra, Lophoceramica, Trichopolia, and Tricholita.

Eyes uniformly hairy

Group 4—Margin of the fore wing produced—Perigonica, Pastona, and Hypotrix.

Group 5—Margin not produced, fore tarsi with enlarged spines—Epia and Admetovis.

Group 6—Margin not produced, tarsi without enlarged spines. This group can be divided as follows:

Section A—Frons uniformly rounded

Subsection I—Antennæ simple in both sexes (filiform).

(a) Antennæ of the male oval in cross section—Anarta, Chabuata, Ulolonche, Aletia, Zosteropoda, and Neleucania, Melanchra.

(b) Antennæ of the male wedge-shaped in cross section—Hadena, Eriopyga, Pseudorthodes, Naesia, Borolia?, Meliana, and Heliophila.

Subsection II—Antennæ of the male never filiform—Morrisonia, Xylomyges, Himella, Alysia, Hyperepia, Nephelodes, Monostola, Characas, Haderonia, Epineuronia, Acerra, Stretchia.

Section B—Frons not uniformly rounded

Subsection Ia—Antennæ of the male never filiform—Perigrapha, Xylomania, Engelhardtia, Lasiestra, and Eurypsyche.

Subsection Ib—Antennæ of the male filiform—Cardepia, Trichocosmia, Barathra, Scotogramma, Dianthoecia, Sideridis and Neuria.

Subsection IIa—Frons ornamented or excavated, antennæ of the males simple—Xanthopastes, Craterestra, Discestra, Cea, and Trichoclea.

Subsection IIb—Frons ornamented but the antennæ in both sexes not simple—Ichneutica and Miodera.

Group I

This group includes Mamestra Ochs. and its equivalent Copimamestra Grote. At first the writer considered *Noctua persicariæ* Linn. as the genotype of Mamestra on the basis of Westwood's designation in 1839 (Synopsis of the Genera British Insects, page 95.) but Dr. McDunnough of the Canadian Bureau of Entomology pointed out to the writer that the type was designated 1829 by Duponchel as *Noctua brassicæ* Linn. (Godart's and Duponchel's Historie Naturelle des Lepidopteres, VII, Part II, pp. 71–72.) In 1883, Grote erected the genus Copimamestra in which he included *brassica* Linn and a new species *occidenta* Grt. He mentions the curved claw on the fore tibia as the chief characteristic and goes on to say, "The types are the European *C. brassicæ* and the following new species." Hampson in 1905 designated *brassicæ* as the type of Copimamestra which is in harmony with Grote's statement so it may be considered as genotype of Copimamestra. This makes Copimamestra the equivalent of Mamestra, both having the same species for genotype.

Noctua brassicæ Linn has the characteristic hairy eyes of a Hadenine but also possesses the unusual claw-like structure on the fore tibia. This is an outstanding character which should serve to identify the genus.

Synopsis of Morphological Characters

Head:

Vestiture 2, Compound eyes 3, Frons 2, Antennæ male 1 hair beneath, of the female 1 ciliated beneath, Vestiture of the palpi 4, Ratio of the palpal segments 2, proboscis 1.

Thorax:

Vestiture 2, Crests 5, Primaries costa 1, apex 1, outer margin 1 (incurved), Secondaries 1, Vestiture of the fore leg 1, structure 2, Vestiture of middle and hind legs 1, structure of middle and hind legs 1.

Abdomen:

Vestiture 6, Dorsal crests in male 7 (1st to 5th), in the female 3, Lateral crests in the male 2, in the female 1.

Group II

In this group may be placed three genera, Eubuchholzia, Ommatostola, and Parameana. The type of Eubuchholzia is *Arsilonche colorada* Smith, of Ommatostola is *O. lintneri* Grt., and of Parameana, *Hadena laetabilis* Smith. In these three species the fore tibiæ are without the claw found in Group I but the eyes are either naked or apparently so. The hairs between the facets are so small and so few in number that it is very easy to overlook them.

These genotypes can be separated in the following way:

1. Frons rather uniformly rounded 2
   Frons projects forward and upward, frontal surface convex. Parameana B. & Benj.
2. Antennæ of the male filiform Eubuchholzia B. & Benj.
   Antennæ of the male serrate Ommatostola Grt.

Synopsis of Morphological Characters

	Parameana	Eubuchholzia	Ommatostola
Head:			
Vestiture	3	2	3
Compound eyes	1	1	1
Frons	13	1	1
Antennæ of male	×	2, hair and setæ beneath	9
Antennæ of the female	2, ciliated, no setæ beneath	×	1, cilia and lateral and midventral setæ
Vestiture of palpi	4	4	2
Ratio of palpal segments	2	2	2
Proboscis	1	1	1
Thorax:			
Vestiture	3	3	2
Crests	4	4	4
Costa of primaries	1	1	1
Outer margin of primaries	1, incurved	1, incurved	1, incurved
Apex of primaries	2	3	2
Sc. and R of secondaries	2	1	1
Fore leg—vestiture	1	1	2
" " —structure	1	1	1
Middle leg—vestiture	1	1	2

" " —structure	1	1	1
Hind leg—vestiture	1	1	2
" " —structure	1	1	1
Abdomen:			
Vestiture	6	4	7
Dorsal crests	3	1	1
Lateral crests	1	2	3

Group III

In this group we have four genera which are more typically Hadenine in character. The fore tibiæ are not spurred and the eyes are markedly hairy but the hair in these genera is confined to the posterior portion of the eye. This group consists of the following genera: Ursogastra Smith (type *lunata* Smith), Lophoceramica Dyar (type *artega* Barnes), Tricholita Grote (type *semiaptera* Morr.), and Trichopolia Grote (type *dentatella* Grote). By looking over the synopsis of morphological characters, one will see that all four genotypes have much in common and that the best way to separate them on the basis of the structure of the antennæ. This may be done in the following way:

1.	Antenna of the male filiform	Ursogastra Smith
	Antenna of male not filiform	2
2.	Antenna of male bipectinate, pectinations the same size on both sides	3
	Antenna of the male bipectinate and serrate, pectinations not of the same size on both sides of the shaft	Trichopolia Grote
3.	Antenna of the female filiform	Lophoceramica Barnes
	Antenna of the female bipectinate	Tricholita Grote

Group IV

Members of this group have the eyes uniformly hairy, fore tibia without a claw. The outstanding characteristic in this section is the shape of the fore wings for in each of these genotypes the outer margin of the upper wings is produced. Here we find the genus Perigonica Smith-type *angulata* Smith, Pastona Walk.-type *rudis* Walk, and Hypotrix Gn.-type *purpurigera* Gn. *Rudis* and *purpurigera* are Brazilian species and the genera of which they are the types may have no representatives in North America. The genus Magusa of Walker has for its type *albiguttalis* Walker. According to Hampson, *albiguttalis* is a synonym of *rudis* so

Synopsis of Morphological Characters

	Ursogastra	Lophoceramica	Tricholita	Trichopolia
Head:				
Vestiture	3	2	2	2
Compound eyes	2	2	2	2
Frons	1	1	1	1
Antennæ, male	1, under side flat, hairy, lateral setæ	22	22	14
Antennæ, female		1, under side ciliated, lateral setæ	9	1, under side ciliated, lateral setæ
Vestiture of palpi	3	4	4	4
Ratio of palpal segments		2	2	1
Proboscis	1	1	1	1
Thorax:				
Vestiture	2	2	2	3
Crests	4	5	5	5
Costa of primaries	1	1	1	1
Apex of primaries	3	1	2	1
Outer margin of primaries	1, incurved	1, incurved	1, straight	1, straight
Sc and R of secondaries		2	2	1
Fore leg—vestiture	1	1	1	1
" " —structure	1	1	1	1
Middle leg vestiture	1	1	1	1
" " structure	1	1	1	1
Hind leg—vestiture	1	1	1	1
" " —structure	1	1	1	1
Abdomen:				
Vestiture	7	4	4	4
Dorsal crests	1	3	3	3
Lateral crests	3	3 male, 2 female	3	3 male, 1 female

Magusa sinks as a synonym of Pastona. The genera may be separated in the following way:

1.	Antenna of the male serrate, almost bipectinate	Perigonica Smith
	Antenna of the male filiform	2
2.	Apex of the fore wing rounded	Pastona Walk.
	Apex of the fore wing drawn down to a point	Hypotrix Gn.

Synopsis of Morphological Characters

	Perigonica	Pastona	Hypotrix
Head:			
Vestiture	1	3	1
Compound eyes	3	3	3
Frons	1	1	1
Antenna of the male	10	1, ciliated beneath lateral setæ	1, ciliated beneath lateral setæ
Antenna of the female	1, ciliated lateral setæ	1, fine cilia lateral setæ?	1, ciliated lateral setæ
Vestiture of the palpi	4	3	4
Ratio of the palpal segments	2	x	x
Proboscis	1	1	1
Thorax:			
Vestiture	2	3	3
Crests	5	5	5
Costa of primaries	1	1	1
Apex of primaries	4	2	3
Outer margin primaries	5	3	4
Sc. and R. of secondaries	x	x	x
Fore leg—vestiture	1	1	1
" " —structure	1	1	1
Middle leg—vestiture	1	1	1
" " —structure	1	1	1
Hind leg—vestiture	1	1	1
" " —structure	1	1	1
Abdomen:			
Vestiture	6	7, male, 4, female	6, male, 4, female
Dorsal crests	2	1	1
Lateral crests	3	1	1

Group V

In this group we find two genera—Epia Hubner whose type is *echii* Bork, and Admetovis Grote with *oxymorus* Grote as its type. The first of these species is European and the genus may not be represented in this country. The other is native to the United States. Both species have the eyes uniformly hairy, fore tibiæ without a claw, and wing formal normal. The outstanding characteristic is the enlarged spines on the fore tarsi. If this character is not constant, then the species will fall in the next group. *Echii* has the frons protruding somewhat forward and downward with indications of "T" shaped protuberance. *Oxymorus* has the frons uniformly rounded. In *echii* the first tarsal segment of the fore tibia has a large curved spine near its distal end and all spines on the first and second tarsal segments are overdeveloped. In *oxymorus* the first tarsal segment of the fore tibia has at least three large spines on the outer side. On the succeeding two segments the spines are overdeveloped.

Synopsis of Morphological Characters

	echii	*oxymorus*
Head:		
Vestiture	2	2
Compound eyes	3	3
Frons	5	1
Antenna of the male	1, long hair and lateral setæ	2, long hair and lateral setæ
Antenna of the female	1, ciliated with lateral setæ	1, ciliated with lateral setæ
Vestiture of the palpi	2	4
Ratio of the palpal segments	2	2
Proboscis	1	1
Thorax:		
Vestiture	2	3
Crests	5	5
Costa of primaries	1	1
Apex " "	2	1
Outer margin "	1, straight	1, incurved
Sc. and R. secondaries	2	2

Fore leg—vestiture	1	1
" " —structure	3	7
Middle leg—vestiture	1	1
" " —structure	1	1
Hind leg—vestiture	1	1
" " —structure	1	1
Abdomen:		
Vestiture	4	6, male; 4, female
Dorsal crests	3	7
Lateral crests	3	2

Grote, in his original description of Admetovis mentions the pectinated condition of the antenna of the male. In specimens examined by the writer, the antenna was filiform. Smith, in Bull. 44, U. S. Nat. Mus. says, "The right of Admetovis to generic rank is decidedly questionable."

Group VI

In this group we find the greatest number of genera. Their genotypes have the eyes uniformly hairy, tibiæ without claws or spines, margins of the fore wings not produced. The species can be easily separated on the bases of their frons. In section A the frons is uniformly rounded, in section B the frons is produced sometimes forming some type of ornamentation.

Section A

Subsection I—Antennæ filiform in both sexes. Filiform antennæ are of two types. In one type the antenna is round or oval in cross section, in the other type ventral surface of each segment is raised to form a keel giving the antenna a wedge-shaped appearance when seen in cross section.

Subsection Ia—Antennæ of male oval

Costal margin of the fore wing straight	1
Costal margin of the fore wings lobed at the base	Ulolonche Smith
Costal margin of the fore wings concave	2

1. All segments of the palpi bearing scales only.
Hyphilare Hub., Ceramica Gn., Chabuata Walk., Aletia Hub.
Some segments of the palpi bearing a mixture of hair and scales 1a

1a.	Apex of the fore wing pointed	Meterana Butler
	Apex of the fore wing rounded	Melanchra Hub., Hyssia Gn.
2.	All segments of the palpi bearing scales only	Neleucania Smith
	Some segments of the palpi bearing a mixture of hair and scales	2a
2a.	Apex of the fore wings truncated	Anarta Ochs.
	Apex of the fore wings pointed	Zosteropoda Grote

Hyphilare, Ceramica, Chabuata, and Aletia

Hyphilare albipuncta Schiff., *Ceramica picta* Harris, *Chabuata ampla* Walk., and *Aletia vitellina* Hub. are the four genotypes. *Albipuncta* and *vitellina* are European; *picta,* North American; and *ampla* is found in Brazil. It is easy to understand why *Ceramica picta* is included in this article but a few words of explanation are needed to justify the inclusion of the others. All four species plus *Meterana pictula, Melanchra persicariae,* and *Hyssia cavernosa* have been considered associated with the genus Mamestra. Many workers, including the writer, have accepted Westwood's designation of the genotype of Mamestra as *persicariæ* Linn. (Westwood, "Synopsis of the Genera of British Insects," p. 95, 1839–1840.) Dr. McDunnough of Canada informed the writer that the type of Mamestra was designated in 1829 by Duponchel as *brassicæ* Linn. Since *brassicæ* has a curved claw on the fore tibia, the genus Mamestra does not fit with these genera and the next oldest genus to take its place is Melanchra of Hubner with *persicariæ* as its type—a monotypical genus. Melanchra with its palpi clothed with both scales and hair differs from Hyphilare, Ceramica, Chabuata, and Aletia, in which all the palpal segments are covered only with scales. These four will be considered first. In looking over the synopsis of morphological characters below, it will be noted that all four genotypes have much in common with each other yet not one agrees entirely with any other one. Hyphilare, Ceramica and Aletia resemble each other in most respects and Chabuata stands off a bit by itself but not very distant so far as morphology is concerned. Our genus Ceramica may have to sink as a synonym of Hyphilare or Aletia if one would stress structure rather than coloration or wing patterns. See, however, a discussion of Ceramica under section pertaining to male genitalia.

Synopsis of Morphological Characters

	Hyphilare	Ceramica	Chabuata ♀	Aletia ♀
Head:				
Vestiture	2	2	1	2
Compound eyes	3	3	3	3
Frons	1	1	1	1
Antennæ of the male	1, long hair beneath	1, long hair lateral setæ	×	×
Antenna of the female	1, cilia	1, cilia	1, cilia lateral setæ	1, cilia lateral setæ
Vestiture of the palpi	1	2	2	2
Ratio of the palpal segments	3	3	×	2
Proboscis	1	1	1	1
Thorax:				
Vestiture	2	2	2	2
Crests	2	5	5	2
Costa of the primaries	1	1	1	1
Apex of the primaries	1	1	3	1
Outer margin of primaries	1, straight	1, incurved	1, straight	1, incurved
Sc. and R. of secondaries	2	2	×	2
Fore leg—vestiture	1	1	1	1
" " —structure	1	1	1	1
Middle leg—vestiture	1	1	1	1
" " —structure	1	1	1	1
Hind leg—vestiture	1	1	1	1
" " —structure	1	1	1	1
Abdomen:				
Vestiture	1 male, 4 female	6	4	1
Dorsal crests	2	2	3	2
Lateral crests	3 male, 1 female	3	1	1

Genus Ulolonche Smith

The type of this genus, *Ulolonche niveiguttata* Grote, exhibits many of the characters of the Melanchra group with the exception of the peculiar shape of the costa of the fore wings. It also appears to be related to the Hyphilare group. Owing to this dual relationship, the genus Ulolonche has been placed here between those two groups.

Synopsis of Morphological Characters

Head:

Vestiture 2, Compound eyes 3, Frons 1, Antennæ of the male 1 fine hair and lateral setæ beneath, in the female 1 ciliated and with lateral setæ beneath; Vestiture of the palpi 4, Ratio of the palpal segments 2, Proboscis 1.

Thorax:

Vestiture 3, Crests 3, Costa of the primaries 2, apex of primaries 2, outer margin of primaries 1 incurved, Sc. and R. of the Secondaries 2, Vestiture and structure of all legs 1.

Abdomen:

Vestiture 6, Dorsal crests 3, Lateral crests in male 3, in female 2.

Melanchra, Meterana, and Hyssia

The three genotypes—*Melanchra persicariæ* L., *Meterana pictula* White, and *Hyssia cavernosa* Evers—have at least one palpal segment clothed with a mixture of hair and scales and in this way at least they differ from the genotypes of the Hyphilare group. *Persicariæ* is European, *pictule* comes from New Zealand, and *cavernosa* is a Russian species. They are included here because the genera they represent have been erroneously associated with the genus Mamestra. In fact if we were to accept *persicariæ* as type of Mamestra, then Melanchra would sink as a synonym of that genus having the same species as its genotype. If we compare the three genotypes structurally, it will be noted that Meterana has five characters in common with Melanchra while Hyssia has only three. In making this comparison one should eliminate the six characters common to all three species. On

Synopsis of Morphological Characters

	Melanchra	Meterana	Hyssia
Head:			
Vestiture	3	3	2
Compound eyes	3	3	3
Frons	1	1	1
Antenna of the male	1 ciliated lateral setae	×	1 long hair lateral setae
Antenna of the female	1 ciliated lateral setae	1 ciliated lateral setae	1 ciliated lateral setae
Vestiture of the palpi	4	4	5
Ratio of the palpal segments	3	2	2
Proboscis	1	1	1
Thorax:			
Vestiture	3	2	2
Crests	5	2	5
Costa of the primaries	1	1	1
Apex of the primaries	2	3	2
Outer margin of the primaries	1 incurved	1 incurved	1 straight
Sc. and R. of the secondaries	2	2	2
All legs structure and vestiture	1	1	1
Abdomen:			
Vestiture	6	6	4
Dorsal crests	7	3	2
Lateral crests	2	3	2

Synopsis of Morphological Characters

	Neleucania	Anarta	Zosteropoda
Head:			
Vestiture	2	1	1
Compound eyes	3	3	3
Frons	1	1	1
Antenna of the male	1 ciliated	1 hair and lateral setae	1 hair, lateral mid ventral setae
Antennæ of the female	1 ciliated lateral setae	1 ciliated lateral setae	1 cilia lateral mid ventral setae
Vestiture of the palpi	1	4	3
Ratio of palpal segments	×	2	1
Proboscis	1	1	1
Thorax:			
Vestiture	2	2	1
Crests	6	3	1
Costa of primaries	4	4	4
Apex of primaries	3	1	3
Outer margin of primaries	1 incurved	1 incurved	1 incurved
Sc. and R. of the secondaries	×	2	1
Vestiture and structure of all legs	1	1	1
Abdomen:			
Vestiture	4	6	4
Dorsal crests	3	5	1
Lateral crests	1	2	1

the same basis Meterana and Hyssia have two characters in common. All this would indicate a close relationship among the three genera so far as their genotypes are concerned.

Neleucania, Anarta and Zosteropoda

The genotypes of these three genera are *Neleucania niveicosta* Smith, *Anarta myrtilli* Linn., and *Zosteropoda hirtipes* Grote. In these three species the costa of the primaries is concave, an unusual character in this subfamily. *Myrtilli* is the only European species the other two being native to the United States. All three genera are represented in this country however. Neleucania can be readily separated from the other two by the vestiture of the palpi. In this genus the palpal segments are clothed with scales only, in the other two at least one segment is covered with a mixture of scales and hair.

Subsection Ib Antenna of Male Wedge-shaped

In this substance the writer has placed fourteen genera one of which may have to be removed upon further study —genus Borolia Moore. All of the genotypes have much in common morphologically with the Melanchra group but there we find that the antennæ of the males, while filiform in structure, are more or less oval in cross-section while in this subsection—the Hadena like moths—the filiform antenna of the males is wedge shaped in cross section. Whether this is sufficient ground for separating the Melanchra and Hadena groups must be left to the reader. Probably it is best to consider this as an artificial grouping for convenience. The genotypes included in this subsection are as follows:

Hadena Schrank—type *cucubali* Schiff.
Aethria Hubner—type *serena* Schiff.
Astrapetis Hubner—type *dentina* Schiff.
Dargida Walk—type *grammivora* Walk.
Diataraxia Hub.—type *splendens* Hub.
Eupsephopaectes Gr.—type *procinctus* Gr.
Crocigrapha Gr.—type *normani* Gr.
Aplecta Gn.—type *nebulosa* Hufn.
Eriopyga Gn.—type *punctulum* Gn.

Pseudorthodes Morr.—*vecors* Gn.
Naesia Walk.—type *moesta* Walk.
Borolia Moore—*furcifera* Moore.
Meliana Curtis—*flammea* Curt.
Heliophila Hub.—*pallens* Linn.

These genotypes may be separated more or less satisfactorily in the following way:

A. Primaries with the costal margin slightly convex.
  1. Legs compactly scaled . . Meliana
     Some of the segments of the legs bearing hair and scales 2
  2. Apex of the primaries drawn to a point . Eriopyga
     Apex truncated 3
  3. All palpal segments bearing scales only Borolia
     Some palpal segments bearing hair and scales . Næsia
B. Primaries with the costa straight.
  1. Vestiture of the head hair only Heliophila
     Vestiture of the head hair and scales or scales 2
  2. No dorsal abdominal crests, wings short and stubby. Pseudorthodes
     Dorsal abdominal crests present, wings narrower Hadena group

Meliana, Eriopyga, Borolia and Naesia

These four genotypes are grouped together on the basis of their convex costal margin. Meliana can be separated from the other three on the vestiture of the legs. All the legs of *Meliana flammea* are compactly scaled which is not a common character in this subfamily. The other three genotypes in this group have some portion of some of the legs covered with a mixture of hair and scales. *Meliana flammea* is a European species and the genus may be represented in this country. *Borolia furcifera* comes from India and is the type of a genus which is considered to be synonymic with Meliana. The closely scaled legs in Meliana would separate it from Borolia. Borolia however may stand very close to our genus Heliophila from which it differs in the form of the costal margin of the fore wing-convex in Borolia, straight in Heliophila. *Eriopyga punctulum* Gn. and *Naesia moesta* Walk. are both South American species typical of genera which have been confused with Himella and Pseudorthodes. Pseudorthodes with its short stubby wings, and Himella in which the antenna of the male is crenulated can not be confused with their South American neighbors.

Synopsis of Morphological Characters

	Eriopyga	Naesia	Borolia ♀	Meliana
Head:				
Vestiture	2	3	3	2
Compound eyes	3	3	3	3
Frons	1	1	1	1
Antenna of the male	2 hair and lateral setae	2 hair and lateral setae	×	2 hair and lateral setae
Antenna of the female	1 celia and lateral setae	1 cilia and lateral setae	1 cilia and lateral cilia	1 cilia, lateral mid ventral setae
Vestiture of the palpi	2	4	2	2
Ratio of the palpal segments	×	2	3	3
Proboscis	1	1	1	1
Thorax:				
Vestiture	2	2	2	1
Crests	2	3	2	1
Costa of primaries	3	3	3	3
Apex of primaries	3	1	1	3
Outer margin of primaries	incurved	incurved	incurved	incurved
Sc. and R. of the secondaries	×	1	2	2
Vestiture of legs	1	1	1	2
Structure of legs	1	1	1	1
Abdomen:				
Vestiture	4	4	4	4
Dorsal crests	3	1	1	1
Lateral crests	1	1	1	1

Heliophila Hubner

The type of this genus is the European species *pallens* of Linneaus. The genus is well represented in this country but many of the species are difficult to identify because they resemble each other so markedly. The genus Leucania of Ochsenheimer has *pallens* as its type so it sinks as a synonym of Heliophila.

Synopsis of Morphological Characters

Head:

Vestiture 1, Compound eyes 3, Frons 1, Antenna of the male 2 with hair and lateral setae, in the female 1 ciliated with lateral setae, Vestiture of the palpi 2, Ratio of the palpal segments 2, Proboscis 1.

Thorax:

Vestiture 2, Crests 1, Costa of the primaries 1, Apex of primaries 3, Outer margin of primaries straight, Sc. and R. of the secondaries 2, Structure and vestiture of all legs 1.

Abdomen:

Vestiture 4, Dorsal crests 1, Lateral crests 1.

Pseudorthodes Morrison

This genus has for its type the American species *vecors* Guenee. In many ways it resembles morphologically the genus Crociagrapha but the shorter more stubby wings of *vecors* will serve to separate the two genera.

Synopsis of Morphological Characters

Head:

Vestiture 2, Compound eyes 3, Frons 1, Antenna of the male 2 short hair and lateral setae, in the female 1 ciliated with lateral setae, Vestiture of palpi 4, Ratio of the palpal segments 1 and in some specimens 2, Proboscis 1.

Thorax:

Vestiture 2, Crests 3, Costa of the primaries 1, Apex of the primaries 2, Outer margin of primaries straight, Sc. and R. of the secondaries 1, Vestiture and structure of all legs 1.

Abdomen:

Vestiture 4 in one female 7, Dorsal crests 1, Lateral crests in the male 3, in the female 1.

The Hadena Group

Associated with Hadena are seven other genera all of which have much in common with Hadena. One is tempted to separate them on the basis of coloration and marking but if we try to establish genera on purely morphological characters then some, if not all, of the six genera will have to sink as synonyms of Hadena. Of the eight genotypes three are North American species—*Dargida grammivora*,* *Crocigrapha normani*, and *Eupsephopaectes procinctus*. The other five are Europeon. Below is a synopsis of morphological characteristics of the eight types and the reader may use his own judgment as to which ones, if any, he wishes to consider valid and which he will look upon as synonymic with Hadena.

A summary of the morphology of the four European genera is presented in tabular form.

Dargida differs from Hadena in having two palpal segments bearing scales only, one thoracic crest, outer margin of the primaries incurved, and dorsal abdominal crests indistinct. Eupsephopaectes can be separated from Hadena in the following ways —vestiture of head scales, proximal and middle palpal segments bearing only scales, vestiture of the thorax hair and scales, and one dorsal abdominal crest. Crocigrapha shows many points of difference when compared with Hadena. Crocigrapha has the proximal and middle segments bearing scales only, vestiture of the thorax hair and scales, indistinct pro- and a more evident meta-thoracic crests, apex of the primaries rounded, abdomen covered dorsally and ventrally with hair and scales, and a single dorsal abdominal crest. These may be sufficient reasons for considering the three genera distinct from Hadena.

Subsection II Antenna of the Male Never Filiform

In this section are twelve genotypes the males of which have antennæ that vary from crenulate to bipectinate. All of these are quite distinct with the exception of Monostola which stands very close to our American genus Nephelodes. The twelve genera, their genotypes, and the habitat of the genotypes are presented.

* *graminivora* (lapsus calami).

Synopsis of Morphological Characteristics

	Hadena	Dargida	Eupsephopaectes	Crocigrapha
Head:				
Vestiture	2	2	3	2
Compound eyes	3	3	3	3
Frons	1	1	1	1
Antenna of male	2 hair and lateral setae	as in Hadena	as in Hadena	as in Hadena
Antenna of female	1 cilia and lateral setae	as in Hadena	as in Hadena	as in Hadena
Vestiture of palpi	3	4	4	4
Ratio of palpal segments	3	3	2	2
Proboscis	1	1	1	1
Thorax:				
Vestiture	3	3	2	2
Crests	5	2	5	3
Costa of the primaries	1	1	1	1
Apex of primaries	1	1	1	2
Outer margin of primaries	straight	incurved	straight	straight
Sc. and R. of the secondaries	2	1	2	1
Vestiture and structure all legs	1	1	1	1
Abdomen:				
Vestiture	4	5♂ 4♀	4	6
Dorsal crests	7	2	4	3
Lateral crests	3♂ 1♀	3♂ 1♀	3	3

Synopsis of Morphological Characteristics

	Aethria	Astrapetis	Diataraxia	Aplecta
Head:				
Vestiture	2	2	3	3
Compound eyes	3	3	3	3
Frons	1	1	1	1
Antenna of male	2 hair no setae	as in Hadena	as in Hadena	2 ciliated lateral setae
Antenna of female	as in Hadena	as in Hadena	as in Hadena	as in Hadena
Vestiture of palpi	4	4	4	2
Ratio of palpal segments	2	2	3	2
Proboscis	1	1	1	1
Thorax:				
Vestiture	3	2	2	3
Crests	4	3	5	5
Costa of primaries	1	1	1	1
Apex of primaries	2	1	1	1
Outer margin of primaries	straight	incurved	straight	straight
Sc. and R. of secondaries	2	2	2	2
Vestiture and structure all legs	1	1	1	1
Abdomen:				
Vestiture	6	2♂ 4♀	4	6
Dorsal crests	2	7	7	3
Lateral crests	2	3♂ 2♀	2	1

Morrisonia Grote—type evicta Grt.	U. S. A.
Xylomyges Gn.—type conspicillaris Linn.	Europe
Himella Grt.—type fidelis Grt.	U. S. A.
Alysia Gn.—type specifica Gn.	Australia, New Zealand
Hyperepia Barnes & Lindsey—type pi B. & L.	U. S. A.
Nephelodes Gn.—type emmedonia Cram. (minians Gn.)	U. S. A.
Monostola Alpheraky—type asiatica Alph.	Asia
Charaeas Steph.—type cespitis W. V.	Europe
Haderonia Staud.—type subarschanica Staud.	Europe
Epineuronia Staud.—popularis Fab.	Europe
Acerra Grt.—normalis Grt.	U. S. A.
Stretchia Hy. Edw.—type plusiaeformis Hy. Edw.	U. S. A.

Remarks

A word or two regarding some of these genotypes may clear up a few questions in the mind of the reader. Both Smith and Guenee allowed some range of variation in the type of antenna to be found in the genus Xylomyges. Probably it would be best to restrict the genus to those species in which the antenna of the male is serrated. Hampson would place *conspicillaris* under the genus Xylomania but in the structure of the antenna of the male and female they are both quite distinct.

In the case of Alysia, Hampson would combine it with Ulolonche and make them synonymous with Hyssia. In the type of male antenna, Alysia is distinctive and probably stands close to our American genus Himella.

Nephelodes has at least one synanym—Monosca Walker. Monosca, like many of Walker's genera, is a monotypical genus with subnotata Walker as its type. According to Hampson *subnotata* Walker is a synonym of *emmedonia* Cramer (*minians* Gn.) so both Nephelodes and Monosca have the same genotype. *Monostola asiatica* is in coloration and marking very much like *emmedonia* but structurally there are some differences. The most outstanding differences are in the vestiture of the head, type of antennae in the males, development of the proboscis, and thoracic crests.

Synopsis of Morphological Characters

	Morrisonia evicta Grt.	*Xylomyges conspicillaris* W. V.	*Himella fidelis* Gr.	*Alysia specifica*	*Hyperæpia pi* B. & L. ♂	*Nephelodes minians* Gn.	*Monostola asiatica* Alph. ♂	*Charaeas cespitis* W. V.	*Haderonia subarschanica* Staud.	*Epineuronia popularis* Fab.	*Acerra normalis* Grt.	*Stretchia plusiaeformis* H. Edw.
Head:												
Vestiture	2	2	2	1	3	2	1	2	2	2	1	2
Compound eyes	3	3	3	3	3	3	3	3	3	3	3	3
Frons	1	1	1	1	1	1	1	1	1	1	1	1
Antenna of male	5	4	6	7	12	11	23	20	14	24	15	13
Antenna of female	1	1	1c	1a	×	1b	×	1	1	3	5	8
Vestiture of palpi	4	4	4	4	4	2	4	4	4	4	2	5
Ratio of palpal seg.	2 and 3	2	1	2	2	2	2	2	1	2	1	2
Proboscis	1	1	1	1	1	1	2	2	1	2	1	1
Thorax:												
Vestiture	3	3	2	1	3	2	1	3	3	2	1	2
Crests	5	5	1	1	5	5	1	5	5	1	5	5
Primaries—costa	1	1	3	1	1	1	1	1	1	1	1	1
" —apex	1	3	1	1	1	1	1	1	2	1	3	2
" —outer margin	straight	straight	straight	incurved	straight	straight	straight	2	incurved	straight	slightly incurved	slightly incurved

	Morrisonia evicta Grt.	*Xylomyges conspicillaris* W. V.	*Himella fidelis* Gr.	*Alysia specifica*	*Hyperepia pi* B. & L. ♂	*Nephelodes minians* Gn.	*Monostola asiatica* Alph. ♂	*Charaeas cespitis* W. V.	*Haderonia subarschanica* Staud.	*Epineuronia popularis* Fab.	*Acerra normalis* Grt.	*Stretchia plusiaeformis* H. Edw.
Secondaries Sc. & R . . .	2	1	1	1	2	2	1	1	1	1	1	1
All legs—structure	1	1	1	1	1	1	1	1	1	1	1	1,see note
" " —vestiture	1	1	1	1	1	1	1	1	1	1	1	1
Abdomen:												
Vestiture	6	6	5♂ 4♀	2	4	4	6	4	6	6♂ 4♀	6	6
Dorsal crests	1♂ 3♀	3	1	1	3	4♂ 2♀	4	4♂ 2♀	6	3	3	3
Lateral crests	3♂ 1♀	3	3♂ 1♀	3	3	3♂ 1♀	1	1	1	3	3♂ 1♀	3♂ 1♀

Female antenna: (1) Filiform fine cilia beneath with lateral setae, (1a) as in (1) but flattened beneath, (1b) as in (1) but with mid ventral setae also, (1c) ventral surface covered with short hair lateral setae.

These would serve to separate Nephelodes from Monostola but the two genera are very closely related.

Charaeas has been included because some writers have confused it with Mamestra. In the structure of the fore tibia, the type of male antennae, and other more minor differences the two genera are very distinct. Charaeas belongs here with this group of genera although it may not be represented in this country.

Haderonia has also been confused with Mamestra but a comparison of the two genotypes will serve to separate them easily.

Acerra, Stretchia, and Perigrapha are three genera very closely related and often confused. Perigrapha has been removed from this section on the basis of its frons. Acerra and Stretchia show some points of difference particularly in the form of the antennae of the male and female. Perigrapha serves as a link to connect this section with Section B.

Section B

The genotypes in this section are characterized by having the frons of various forms but never uniformly rounded. This section can be subdivided into two subsections as follows: Subsection I frons produced but not ornamented, and Subsections II frons bearing some form of ornamentation.

Subsection I

Subsection Ia Antenna of the male never simple.

In this section the writer has placed the following genera:

Perigrapha Lederer	type *i-cinctum* Schiff.	Europe
Xylomania Hampson	type *hiemalis* Grote	U. S. A.
Engelhardtia Barnes	type *ursina* Smith	U. S. A.
Lasiestra Hampson	type *phoca* Morsch.	North America
Eurypsyche Butler	type *similis* Butler	India

Perigrapha has many of the characteristics of Acerra and Stretchia but the slightly protuberant frons places it in this section. It serves to connect Sections A and B. Eurypsyche resembles Meliana in many respects but the shape of the frons and structure of the antennæ of the male of this Indian genus removes it from Meliana section.

	Subsection Ia					Subsection Ib						
	Perigrapha i-cinctum Schiff.	*Xylomania hiemalis* Grote	*Engelhardtia ursina* Smith	*Lasiestra phoca* Mosch.	*Eurypsyche similis* Butler	*Cardepia irrisor* Ersch	*Trichocosmia inornata* Grote	*Barathra albicolon* Ochs	*Scotogramma submarina* Grote	*Dianthoecia carpophaga* Bork.	*Sideridis evidens* Hub.	*Neuria reticulata* Linn.
Head												
Vestiture	1	3	1	1	3?	2	3	2	1	2	2	2
Compound eyes	3	3	3	3	3	3	3	3	3	3	3	3
Frons	2	2	2	2	2	2	2	2	2	4	3	3
Antennæ of male	21	18	16	8	3	2a	1a	1	1c	1d	1d	2a
Antennæ of female	8	7	6	1a	x	1b	1c	1a	1b	1b	1b	1b
Vestiture of palpi	4	5	4	4	1	4	2	4	4	3	2	4
Ratio of palpal seg.	1	1 and 2	2	3	3	3♂ 3♀	2	2	2	3	2	1
Proboscis	2	1	2	1	1	1	1	1	1	1	1	1
Thorax												
Vestiture	1	2	1	1	3	3	3	2	2	3	1	3
Crests	5	5	1	1	1?	1	5♂ 4♀	6	5	5	3	5
Costa of primaries	1	1	1	2	3	1	1	1	1	1	1	1
Apex of primaries	1	3	3	1	3	2	2	1	2	1	1	1

SECTION B

	Subsection Ia					Subsection Ib						
	Perigrapha i-cinctum Schiff.	*Xylomania hiemalis* Grote	*Engelhardtia ursina* Smith	*Lasiestra phoca* Mosch.	*Eurypsyche similis* Butler	*Cardepia irrisor* Ersch	*Trichocosmia inornata* Grote	*Barathra albicolon* Ochs	*Scotogramma submarina* Grote	*Dianthoecia carpophaga* Bork.	*Sideridis evidens* Hub.	*Neuria reticulata* Linn.
Outer margin of primaries	straight	incurved	incurved	incurved	incurved	straight	straight	incurved	straight	incurved	incurved	2
Secondaries Sc. & R.	2	1	1	2	2	2	2	1	2	1	2	2
Vestiture of all legs	1	1	1	1	2	1	2	1	1	1	1	1
Structure of all legs	1	1	1	1	1	1	1	1	1	1	1	1
Abdomen												
Vestiture	7	6	6	6	x	4	7	3	4	4	4	4
Dorsal crests	3	3	1	3	x	2	3	3	3	3	3	3
Lateral crests	3	3	1	2♂ 1♀	x	2	1	1	1	3♂ 1♀	2	3♂ 1♀

Antenna of male 1a = hair, lateral no mid ventral setæ; 1b as in 1a but with mid ventral setæ; 1c hair no setæ; 1d hair lateral setæ; 2a wedge shaped, long hair, lateral setæ.

Antenna of female—1a = ciliated, lateral and mid ventral setæ; 1b ciliated lateral setæ only; 1c short hair, lateral, one mid ventral setum.

SECTION B

	Subsection IIa					Subsection IIb	
	Xanthopastes timais Cram	*Craterestra lucina* Druce	*Discestra chartaria* Grote	*Cea immacula* Grote	*Trichoclea decepta* Grote	*Ichneutica ceraunias* Meyrick	*Miodera stigmata* Smith
Head							
Vestiture	2	3	2	3	2	1	4
Compound eyes	3	3	3	3	3	3	3
Frons	7	10	11	12	8	6	9
Antennæ of male	1a	2c	2a	1b	2b	19	17
Antennæ of female	1	1	1	x	1	4	3
Vestiture of palpi	5	2	4	2	4	4	4
Ratio of palpal seg.	2		2	2	2	2	1
Proboscis	2	1	1	1	1	1	1
Thorax							
Vestiture	2	3	3	3	3	1	3
Crests	4	5	3	x	1	1	2
Costa of primaries	3	1	1	1	1	1	1
Apex of primaries	2	3	2	2	2	3	2

SECTION B

	Subsection IIa					Subsection IIb	
	Xanthopastes timais Cram.	*Craterestra lucina* Druce	*Discestra chartaria* Grote	*Cea immaculata* Grote	*Trichoclea decepta* Grote	*Ichneutica ceraunias* Meyrick	*Miodera stigmata* Smith
Outer margin of primaries	straight	incurved	incurved	incurved	straight	straight	incurved
Sc. and R. of secondaries	2	x	1	1	1	1	1
Vestiture of all legs	1	1	1	2	1	1	1
Structure of all legs	1	1	1	1	1 (see Note)	1	1
Abdomen							
Vestiture	4	4	4	7	4	1	6
Dorsal crests	3	6	3	3	3	3	2
Lateral crests	1	2	2	1	2	3	1

Note: In one pair of *Trichoclea decepta,* the fore legs had type 4 structure.

Antenna of Male 1a, hair no setæ; 1b, hair lateral setæ; 2a, wedge shaped hair no setæ; 2b, wedge, lateral setæ; 2c, wedge ciliated lateral setæ.

Antenna of Female 1 ciliated with lateral setæ.

Synopsis of Morphological Characters
(See Chart)

Subsection Ib Antenna of the male filiform (simple).

In this section the writer places the following:

Cardepia Hampson	type *irrisor* Ersch	Russia, Turkestan
Trichocosmia Grote	type *inornata* Grote	U. S. A.
Barathra Hubner	type *albicolon* Ochs	Europe
Scotogramma Smith	type *submarina* Grote	U. S. A.
Dianthœcia Boisd.	type *carpophaga* Bork.	Europe
Sideridis Hubner	type *evidens* Hubner	Europe
Neuria Guenee	type *reticulata* L. (saponariæ De.G.)	Europe

Remarks

Barathra is included here because many writers make it a synonym of Mamestra. Their reason is based on the fact that they consider brassicæ the types of both genera. *Brassicæ* is the type of Mamestra but *albicolon* is the type of Barathra by elimination. *Albicolon* does not have the claw on the fore tibia and cannot be included in Mamestra.

Subsection II

In this subsection the genotypes have the frons either ornamented or excavated. They fall naturally into two groups on the bases of the antennæ of the male.

Subsection IIa

The males in this subsection have some form of simple antennæ. The frons may bear a knob-like protuberance or some type of heart-like prominence. So far as the writer knows, the antennæ of the female is always simple. All of the genera are American and their types are to be found in the United States. For a more detailed discussion of the other morphological characteristics the reader is referred to the chart. *Regnatrix* Grote is the same as *timais* Cramer, so Philochrysa is a synonym of Xanthopastes, both genera having the same species for their types.

Subsection IIb

In this subsection neither males nor females have simple antennæ. Here the writer places two genera:

Ichneutica Meyrick	Type *ceraunias* Meyrick	New Zealand
Miodera Smith	Type *stigmata* Smith	U. S. A.

Incheutica has been included in this article because it has been considered by some as being synonymic with the genus Leucania. In the shape of the frons, and in the structure of the antennæ of the male, it is quite distinct and probably has no representatives in this country. For more details concerning the morphology of these genotypes see the chart.

The Male Genitalia

A study of the male genitalia was made wherever material was available. There is no doubt that these structures exhibit some characteristics of generic value but many of the differences between male genitalia are purely specific and not generic. In order to separate the specific from the generic one should study the genitalia of all the species of all the genera included in this article. Since it was not possible to do this, the writer has not attempted to use the genitalia in his classification. They should, however, form a working basis for future study.

In describing the various parts the writer has followed the nomenclature of F. N. Pierce in his excellent article, "The Genitalia of the Noctuidæ." Pierce's terminology (with modifications from Walker and Crampton) is as follows:

Uncus: (Epiandrium or Epiproct in part) This is a dorsal appendage of the tenth somite. It may be simple, cygnated, tongue shaped, diamond form, spatulate, or forked (mandibulate).

Peniculus: a lobed process on either side of the tegumen which bears a brush of long hair.

Scaphium: a process on the upper side of the anus.

Subscaphium: a process attached to the lower surface of the anus.

Harpe: (Gonapophyses or Gonostyli) Two wing like projections one on each side below the tegumen. The most distal portion Pierce calls the Cucullus. This may be peaked, bifurcate, trigonate, or rounded—the latter term includes the battledore type of Pierce.

Corona: a row of incurved spines at the distal margin of the Harpes.

Marginal Spines: long slender spines on the distal margin of the Harpes.

Protuberances: this term includes the clasper and ampulla arising from the Harpe.

Editum: a finely spined prominence arising usually near the ampulla. This is not always easy to show in the figures.

Clavus: a prominence arising from the base of the Harpe. It may be brush form, rounded, produced, or scobinated.

Ædœagus: the penis sheath which may be ornamented anywhere along its length or at the orifice.

Vesica: an eversable sac sometimes provided with spines or cornuti or other ornamentation. This is not always easy to see, for it may be turned back into the ædœagus.

Juxta: (Pseudosternite ?) Beneath the anal aperture a sheath through which the ædœagus passes. Sometimes this sheath is heavily scleritized.

Vinculum: (The ninth sternite) A ventral scleritized band or ring.

Group I

Mamestra brassicæ Linn. Fig. 4B.

Uncus—tongue shaped; Peniculus—present; Scaphium—slight indications of its presence; Subscaphium—also slightly evident; Harpe—trigonate; Marginal spines—absent; Corona—present; Protuberance—a flap attached to the Harpe; Editum—present; Clavus—slightly produced; Ædœagus—orifice with a hook on one side; Vesica—probably bearing two small cornuti.

Group II

Of the three genotypes included in this group, the genitalia of only two can be illustrated and described.

Ommatostola lintneri Gr. Fig. 12A.

Uncus—simple; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—tends to be trigonate; Marginal spines—present; Corona—present; Protuberances—a very small, poorly chitinized rod and a stiff curved strap; Editum—present;

Clavus—rounded; Ædœagus—orifice scobinated on one side; Vesica—not ornamented.

Buchholzia colorada Sm. Fig. 16A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—flattened, very irregular along its edge; Pollex—present; Marginal spines—a few; Corona—a partial; Protuberances—a weak rod and a thick scleritized rod; Editum—present; Clavus—produced and bearing a curved strap-like organ; Ædœagus—orifice provided with a hook laterally; Vesica—with a band of teeth.

Group III

Four genera constitute this group but only three of them can be figured. The genitalia of *artega* Barnes and *semiaperta* Morr. show marked resemblances in the shape of their harpes while *dentatella* Grote seems to stand off by itself.

(*To be concluded*)

The Biological Control of Insects with a Chapter on Weed Control. By Harvey L. Sweetman, Ithaca, N. Y., Comstock Publishing Company, Inc., 1936. xii + 460 pp. 142 figs. $3.75.

DeGeer, it is recorded, once made the statement before the Academy of Sciences at Stockholm, that, "We shall never be able to guard ourselves against insects but by means of other insects." There is no doubt about entomologists in general, with the possible exception of some investigators holding different opinions, welcoming a book covering a subject that is not only popular but of scientific and practical interest as well. This is the first time that the literature of biological control has been brought together and summarized, and such summaries are of distinct value not only to scientists and specialists who are familiar with the literature, but to students, in giving them a broad background.

Dr. Sweetman's book covers the theoretical basis of biological control, the use of resistant hosts, the use of bacteria, fungi, viruses, protozoa, nematodes, parasitic insects and predatory invertebrate animals, and there are chapters on the use and introduction of insect parasites and predators, the results of biological control experiments and the biological control of pest plants. In all there are fourteen chapters, a glossary, a list of references and an index.

To those occupied with specific phases of investigational work related to biological control, Dr. Sweetman's accounts may seem to be unduly condensed, but it should be remembered that such curtailment was necessary in view of the size of his field. It should also be remembered that in some phases, the conclusions of experimental work are in a more or less fluid state and that new facts are constantly being developed. For example, the artificial culture of *Neoplectana glaseri* is now taking place, not on a potato medium, but on a medium of ground veal, which at present appears to be quite successful and which has distinct advantages over the potato medium. Such changes in technique, however, frequently take place quite suddenly, and can only be incorporated into future editions of text books.

That there is much more to biological control than the mere introduction and dissemination of beneficial species is plainly brought out in Dr. Sweetman's work. It is somewhat discouraging to note, in his chapter on results, that what he considers highly successful control, and successful control, in the United States, have so far been confined to only three cases in California. For example, as far as adequate results are concerned, the biological control of the gypsy moth in this country is still in the experimental stage. Of course, biological control is young. It has very little early history and in years to come, when accurate and adequate data have accumulated, and when true conclusions can be drawn, it may be possible to study such cases comparatively and to arrive at some basic conclusions relative to where and under what conditions biological control is likely to be successful.

Dr. Sweetman's book is carefully and thoughtfully written, and should appeal to all entomologists and teachers of entomology who are anxious to add to their store of information. H. B. W.

THE EFFECT OF SOAP SPRAYS ON PLANTS*

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INTRODUCTION

Soaps in concentration of from 0.1 per cent to 0.5 per cent are at present widely used as spreading and wetting agents with contact poisons such as nicotine (4), pyrethrum (2), derris (3) and others. In concentrations of 1.0 per cent or stronger soap is sufficiently toxic to kill many soft bodied insects and their larvæ (1, 5). High kill of the Japanese beetle was also obtained with 1 per cent and 1.5 per cent soap solutions, as reported by van der Meulen and van Leeuwen (7) and others. Not all plants, however, can stand such high concentrations of soaps. It therefore became important to ascertain the maximum soap concentration that may be sprayed on different plants without injury. Since cocoanut oil soap has been shown to possess (6, 7) higher insecticidal properties than other soaps, potassium cocoanut oil soap was selected for testing. In addition to its higher toxic properties, cocoanut oil soap can be prepared in liquid form containing about 40 per cent actual soap and is readily soluble in cold water. These features make the soap more convenient to apply than the semi-solid soaps which require long standing or heating in order to dissolve in water.

EXPERIMENTAL

Some 54 different varieties including garden, orchard, greenhouse and ornamental plants were sprayed with aqueous solutions of 0.25, 0.5, 1.0 and 2.0 per cent cocoanut oil soap. The spray was applied with a 3 gallon knapsack sprayer. Observations were

* Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

made within two weeks following the spray application. The tests on the outdoor plants were carried out between the 12 and 26 of August, 1932. During this period only two very light rainfalls occurred in the vicinity where the testing was conducted, giving a total precipitation of 0.34 inch. The foliage on the greenhouse plants was not syringed with water during the experiments.

The results, presented in tables 1 and 2 show that 0.25 per cent and 0.5 per cent soap produced no injury to any one of the plants tested; one per cent soap produced injury to 8 varieties of greenhouse plants, 7 varieties of garden plants but none to orchard trees; two per cent soap caused injury to most of the plants ranging from slight to severe.

Following these results it became of interest to study the effect of soap on blossoms. For this purpose 16 ornamental plants in full bloom were sprayed with 0.25 per cent and 0.5 per cent soap. The results in table 3 show that no injury resulted to the flowers

TABLE 1. TESTS WITH VARIOUS CONCENTRATIONS OF COCOANUT OIL SOAP ON GREENHOUSE PLANTS

Name of Plant	Injury from 0.25% & 0.5% Soap	Injury from 1% Soap	Injury from 2% Soap
Begonia	None	None	Slight injury to leaves.
Buddleia	"	Injury to young leaves.	Severe injury.
Crassula	"	None	None
Carnation	"	"	Injury to stems & leaves.
Chrysanthemum	"	"	None
Dracæna	"	"	"
Euphorbia	"	Injury to young leaves.	Severe injury.
English Ivy	"	Injury to young leaves.	Injury to leaves.
Fern (Boston)	"	Injury to leaves.	Severe injury to leaves.
Fern (Whitmanii)	"	Injury to leaves.	Severe injury to leaves.
Hydrangia	"	None	Slight injury.
Poinsettia	"	"	Severe injury.
Snapdragon	"	Injury to leaf tips.	" "
Stevia	"	None	None

of any one of the plants sprayed with 0.25 per cent, while injury occurred on several varieties from the 0.5 per cent solution.

It appears therefore that cocoanut oil soap in concentrations of 0.5 per cent or lower is practically safe to apply on all kinds of plants with the exception of delicate blossoms. When sprays of higher soap concentrations are required it becomes necessary to consider each variety separately, otherwise the less resistant plants may be injured.

TABLE 2. TESTS WITH VARIOUS CONCENTRATIONS OF COCOANUT OIL SOAP ON ORCHARD AND GARDEN PLANTS

Name of Plant	Injury from 0.25% & 0.5% Soap	Injury from 1% Soap	Injury from 2% Soap
Apple	None	None	None
Peach	"	"	Slight injury to foliage.
Cherry	"	"	Slight injury to foliage.
Grape	"	"	Appreciable injury to shoots & foliage.
Beets	"	"	None
Cabbage (red)	"	"	"
Cabbage (green)	"	"	"
Kohl-rabi	"	"	"
Corn	"	"	"
Cucumber	"	"	"
Cantaloupe	"	"	"
Egg Plant	"	No injury.	Injury to blossoms, none to leaves.
Lettuce	"	Injury to leaves.	Severe injury.
Lima Beans	"	None	None
Pumpkin	"	Injury to foliage.	Injury to foliage.
Blackberries	"	Injury to foliage & young shoots.	Injury to foliage & young shoots.
Sweet Potatoes	"	No injury.	Slight injury to foliage.
Squash	"	None	None
Rose	"	"	Injury to young leaves & flowers.
String Beans	"	Slight injury to young leaves.	
Sweet Peas	"	Slight injury to young leaves.	
Tomato (young plants)	"	None	Slight injury.
Tomato (plant in blossom)		"	Injury to blossoms.
Peppers		Injury to leaves.	Injury to leaves.

TABLE 3. TESTS WITH COCOANUT OIL SOAP ON FLOWERING PLANTS IN BLOOM

Name of Plant	Injury from 0.25% Soap	Injury from 0.5% Soap
Canna	None	None
Chrysanthemum, Hardy	"	"
Dahlia, Dwarf	"	"
Daisy	"	"
Delphinium	"	Injury to flowers.
Geranium	"	None
Geranium, Sweet	"	"
Heliotrope	"	"
Hollyhock	"	Injury to flowers.
Ice Plant	"	Injury to flowers.
Marigold	"	None
Petunia	"	Injury to flowers.
Phlox	"	None
Ragged Sailor	"	"
Roses	"	"
Gladiolus	"	Injury to flowers.

SUMMARY AND CONCLUSIONS

Greenhouse, garden, ornamental and orchard plants were sprayed with various concentrations of cocoanut oil soap in order to determine the maximum concentration that can be applied without injury. The results suggest the following conclusions.

1. Concentrations of 0.25 per cent soap caused no injury to blossoms or foliage of any one of the plants tested.

2. Concentrations of 0.5 per cent soap produced no injury to foliage, stems or buds but caused injury to delicate flowers.

3. Concentrations of 1.0 per cent soap produced no injury to orchard trees but produced injury to many greenhouse and garden plants.

4. Concentrations of 2.0 per cent soap produced injury to most of the plants tested.

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This is a compendium prepared coöperatively by American zoologists under the direction of a committee from Section F of the American Association for the Advancement of Science. This committee consisted of Paul S. Galtsoff, Frank E. Lutz, Paul S. Welch, and James G. Needham, Chairman. Would that all committees could justify their existence by such a useful work as this, although I am not sure which group should be commended the more, the committee of four, or the 186 different contributors; perhaps both should receive equal praise. This book on culture methods, which has been in the making since 1933, is invaluable to those interested in the rearing of invertebrate animals and in maintaining live specimens in laboratories. Numerous animals are involved in the recommendations. There is an introduction by James G. Needham, an article on the methods of collecting and rearing marine invertebrates in the laboratory, by Paul S. Galtsoff, another on collecting and rearing terrestrial and freshwater invertebrates, by F. E. Lutz, J. G. Needham, and P. S. Welch, and these are followed by over three hundred articles dealing with the culture of animals from protozoa to chordata. This book is of value and interest to almost everybody in the field of applied biology. And I for one am willing to accept gratefully and without criticism the information that is offered by the numerous contributors, all specialists in their fields.

H. B. W.

SEASONAL TRENDS IN THE RELATIVE ABUNDANCE OF JAPANESE BEETLE POPULATIONS IN THE SOIL DURING THE ANNUAL LIFE CYCLE

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INTRODUCTION

Since 1927 the Japanese Beetle Laboratory at Moorestown, N. J., has conducted, under the immediate supervision of the writer, several series of field surveys to determine the status of Japanese beetle populations in the soil in various parts of the territory known to be generally infested with the insect. One series, designated the "seasonal series," was, in part, planned to show each year the seasonal trends in abundance during the course of the annual developmental cycle of the insect; and another series, called the "periodic series," was designed to show the major changes in population occurring from one year to the next. Only the results obtained in the first series are considered in this paper. However, since these surveys were confined to the section close to the original point of entry of the Japanese beetle into this country, and therefore long subject to infestation, data from a third series of surveys, conducted since 1932 in Salem County, N. J., in cooperation with the New Jersey Department of Agriculture, are also included to show to what extent the same trends hold in more recently infested territory.

LIFE CYCLE OF THE JAPANESE BEETLE

In its present main distribution area, the developmental cycle of the Japanese beetle begins in the summer of one year with the deposition of eggs in the ground by the adult beetles of one generation and terminates in the summer of the succeeding year with the emergence from the ground of the adult beetles of the next generation. There is thus but one generation a year.

In the vicinity of Philadelphia egg deposition extends from the middle or last of June until well along in October, but the number of eggs laid after September 1 is insignificant compared with the number deposited during July and August. Under the usual summer conditions in this area the eggs hatch in from 2 to 3 weeks, and the resulting larvæ grow rapidly, all but a small proportion attaining their full size by the middle of September. The relatively small number of larvæ hatched late in the season grow more slowly because of the lower temperatures, and hence do not become more than half grown before the oncoming of winter precludes any further growth until the following spring. Such retarded larvæ reach their full growth late in May, when the more advanced larvæ are beginning to pupate. The pupæ normally appear about June 1 and are the dominant stage in the soil during much of that month. Under normal temperatures for that time of year, the pupal stage lasts from 10 to 15 days, and shortly after its appearance the adult beetle works its way up through the soil to the surface of the ground and thence either crawls or flies to near-by vegetation, upon which it begins to feed. In the area under consideration the first adult beetles usually appear above ground between June 10 and 20, though ordinarily they do not become abundant until about July 1.

EXPECTED TRENDS IN POPULATION AS JUDGED FROM LIFE HISTORY

From the foregoing it is evident that during the summer all stages of the Japanese beetle are present in the soil, but at other seasons, roughly from September 15 until June 1 of the succeeding year, the population is composed almost or quite exclusively of larvæ, most of which are in the last, or third, larval instar.

Since all but a negligible proportion of the eggs are deposited in the summer, there can be no increase in the insect's population in the soil during the remainder of the annual cycle. Consequently, unless mortality during the summer has been exceptionally heavy, it is to be expected that each year a Japanese beetle population will attain its greatest abundance early in September and that all subsequent changes in numbers will be in the nature of a decrease.

SEASONAL SERIES OF SURVEYS

Method of Making a Survey

In view of the known habitat preferences of Japanese beetle larvæ, which form the predominant stage in the soil-inhabiting populations of the insect, the surveys have been conducted for the most part in permanent grasslands, such as pastures and the "roughs" of golf courses. In such sites it was expected that soil and vegetational conditions would probably remain nearly uniform, thereby making it possible to relate observed changes in population directly to influences associated with the passage of time.

At each point of examination a layer of sod 1 foot square was removed, and the larvæ and other soil-inhabiting stages found in the underlying soil were collected and counted. Several diggings were made over a stated period, and the average number of individuals per digging was then computed. This figure served as an index of the relative abundance of the insect at that point during the period in question.

During the first years of these surveys the examinations of the soil at each station were confined to a small tract of grassy sod, so that any consequent injury to the land, which was privately owned, would be as inconspicuous as possible. It was found, however, that some of the results obtained under such circumstances were far from representative of the general neighborhood, and it thus became necessary at times to shift the site of the examinations. These changes made it questionable how far the results obtained at different times were comparable with one another. To remedy this situation, and since in the meanwhile experience had shown that any sod injury due to the diggings was only temporary, late in 1929 the surveys were extended over much larger areas at nearly all the stations.

Compilation of Data

Since this paper is concerned solely with the more general trends in the changes in abundance of Japanese beetle populations occurring during an average single annual life cycle, no attempt is made to describe these features as observed in any specific year. Instead, the results of all, or a fair proportion of, the years for

which records are available are combined for each period into a single average, which therefore serves as an index of the relative abundance of the insect during that period. The results, as given in table 1 and figure 1, *A*, have been summarized from records of beetle abundance covering 7 consecutive years in a group of 8 stations, 4 in New Jersey and 4 in an adjoining section of Pennsylvania, all situated within 12 miles of the beetle's original point of entry into this country. Since, as implied in the preceding paragraph, the surveys during the first 3 years were conducted under less nearly uniform conditions than those conducted later, the results based upon the last 4 years are listed separately in table 1, and graphically shown in figure 1, *B*, to show how far they substantiate the indications afforded by the full series of records.

In this series of surveys the individual records obtained at each station were summarized each year for every half-monthly interval for which records were available, throughout the annual life cycle. This procedure gave, for each interval in any 1 year, a series of 8 averages of the number of individuals occurring beneath 1 square foot of sod. The common average of all 8 stations for each interval was then obtained. From these common averages for each year the general averages over a term of years were obtained, which afford a good index of the relative size of the population at any given time of the year. The general results obtained in this way are listed in table 1 under the heading "Average number of individuals per square foot, observed."

Besides giving the observed averages computed from the field records, together with their probable errors, table 1 also lists the averages as estimated by inspection from graphs[1] of seasonal

[1] The graphs were first drawn free-hand and, with the exception of the left-hand ascending portion covering the first summer, were then adjusted by successive approximations until the algebraic sum of the deviations of the estimated from the observed averages so closely approximated zero that the difference was negligible (Ezekiel, Methods of Correlation Analysis, p. 132, 1930). On account of the small size of younger larvæ, which form the predominant stage in the soil during July and August, and the consequent difficulty of finding all of them during an examination of the soil, it is believed that the averages obtained during those months are somewhat lower than those obtained early in the fall; hence the writer feels justified in drawing the graphs of summer abundance through or considerably closer to the higher than

trends based upon the observed averages and the relations, in percentages, that the estimated populations in the different half-monthly periods bear to the maximum average population in the first half of September.

DISCUSSION OF RESULTS

Comparison of the percentages listed in table 1, and also of the graphs in figure 1, for the 7- and 4-year series shows a close general agreement as regards the general direction and extent of change at successive intervals throughout the beetle's life cycle.

Perhaps the most noteworthy feature shown is the practical absence of any decrease in the population during the winter, which is generally regarded as the season of heaviest insect mortality. The records of the individual years of this period are, with few exceptions, consistent in this respect. Even after the abnormally cold winter of 1934, the spring surveys revealed in general a beetle population reduced little, if at all, below that found late in the autumn of 1933.[2] Winter therefore seems to have a conserving effect on a Japanese beetle population, tending to maintain it at the general level that it had reached late in the autumn when the larvæ entered hibernation.

Reduction in the population is clearly shown to be coincident with the occurrence of warm weather, and, in so far as it is not caused by the emergence of adults from the ground, which in the area involved usually does not begin much before June 15, is suggestive of biotic agencies as the responsible factor. The conserving action of winter may accordingly be attributed to the inhibiting effect of temperature upon the activities of the associated soil organisms, although it may also be due in part to the relative inaccessibility of the larvæ at this season of the year when, because of the depth at which they hibernate, they are

to the lower averages (table 1, fig. 1). As a result the algebraic sum of the deviations of the estimates from the observed values shows a marked negative trend (−4.3 in the 7-year series; −1.1 in the 4-year series). The standard error of the estimates is ± 0.85 in the 7-year series and ± 0.72 in the 4-year series.

[2] Fox, Henry. Some misconceptions regarding the effects of the cold of February, 1934, on the larvæ of the Japanese beetle, *Popillia japonica* Newman. Jour. Econ. Ent., 28: 154–159. 1935.

TABLE 1. SUMMARY OF SEASONAL SURVEYS TO DETERMINE JAPANESE BEETLE POPULATIONS IN THE SOIL AT HALF-MONTHLY INTERVALS THROUGHOUT THE INSECT'S DEVELOPMENTAL CYCLE

Period[1]	Seven-year series (1927–1934)				Four-year series (1930–1934)			
	Number of square feet examined	Average number of individuals per square foot		Per cent of maximum estimate	Number of square feet examined	Average number of individuals per square foot		Per cent of maximum estimate
		Observed	Estimated			Observed	Estimated	
June 16–30	1726	.1 ± .04	.1	.6	1246	.2 ± .08	.2	1.4
July 1–15	1359	3.0 ± .40	3.0	17.8	816	3.9 ± .42	3.8	25.7
16–31	1592	5.9 ± .69	6.9[2]	40.8	1010	6.7 ± .70	7.0[2]	47.3
Aug. 1–15	1383	8.3 ± .96	10.9[2]	64.5	846	9.2 ± 1.23	10.2[2]	68.9
16–31	1469	14.3 ± 1.69	14.9[2]	88.2	845	13.3 ± 2.12	13.4[2]	90.5
Sept. 1–15	1277	16.9 ± 2.00	16.9	100.0	890	14.8 ± 2.63	14.8	100.0
16–30	1342	16.0 ± 1.47	16.0	94.7	913	13.7 ± 2.00	13.7	92.6
Oct. 1–15	1630	14.9 ± 1.18	14.9	88.2	1138	12.2 ± 1.31	12.3	83.1
16–31	1764	12.5 ± .90	13.9	82.2	1223	10.3 ± .68	12.2	82.4
Nov. 1–15	1272	13.6 ± 1.42	13.4	79.3	878	11.7 ± 1.17	12.2	82.4
Mar. 16–31	1138	13.4 ± 1.45	12.9	76.3	601	12.4 ± 2.23	12.0	81.1
Apr. 16–30	1606	13.4 ± 1.21	12.8	75.7	1025	13.0 ± 1.81	11.9	80.4
May 1–15	1688	12.5 ± 1.24	12.5	74.0	1012	13.0 ± 2.14	11.8	79.7
16–31	1834	11.2 ± 1.00	11.4	67.5	1134	11.1 ± 1.51	11.1	75.0
June 1–15	1937	9.6 ± .77	9.6	56.8	1219	9.6 ± 1.26	9.6	64.9
16–30	1785	7.1 ± .68	6.9	40.8	1078	6.7 ± 1.07	6.7	45.3
July 1–15	1401	2.8 ± .54	2.8	16.6	858	2.0 ± .47	2.0	13.5
16–31	1732	.3 ± .11	.3	1.8	1028	.2 ± .03	.2	1.4
Aug. 1–15	1502	.0 ± .01	.0	.0	903	.0 ± .00	.0	.0

[1] The half-monthly periods from June 16 to August 15 are included twice, pertaining in the first place to the early stages in the beetle's developmental cycle, and in the second to the final stages of the same generation when adults are emerging above ground. Records of the periods between November 16 and March 15, and between April 1 and 15 are incomplete.

[2] Graphs of summer populations passing through observed values usually exhibit a pronounced dip or sag in their middle section. Because of the relatively minute size of the earlier larval stages, which predominate during much of the summer, a somewhat larger proportion of them are doubtless missed in the soil examinations than is the case with eggs (conspicuous because of their white color and relative firmness) or older larvæ. It accordingly seems justifiable to estimate the populations between mid-July and late August at a somewhat higher value than is indicated by the observed averages. This correction is especially called for in the 7-year series, the earlier surveys of which during the summers were conducted under rather unfavorable conditions.

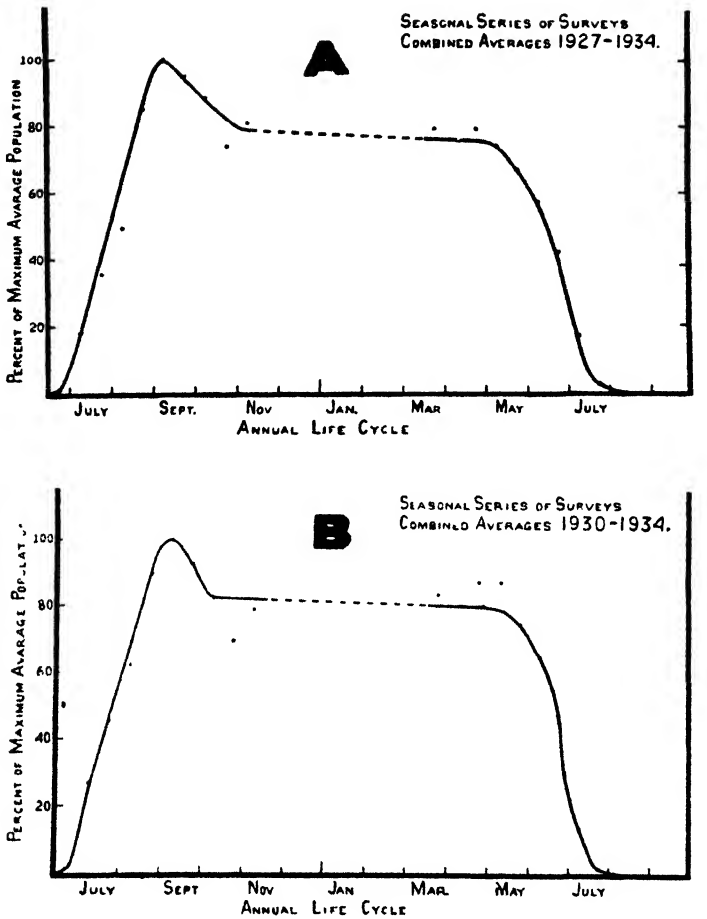


FIGURE 1.— Seasonal trends in the relative abundance of Japanese beetle populations in the soil during the annual life cycle, in percentage of the population for the period September 1–15: *A*, Estimates based upon records of 7 consecutive years (1927–1934) in the seasonal series of surveys; *B*, estimates based upon records of the last 4 (1930–1934) of the 7 consecutive years in the same series of surveys.

largely protected from birds and other animals feeding at the surface.

It is obvious that any mortality in a population during its first summer is normally more than compensated for by the continued

deposition and hatching of eggs. Hence, throughout July and August—the 2 months of active egg laying—the population shows a steady net increase until the maximum population is reached early in September. Thereafter, egg deposition having practically ceased, the decreasing trend in the population is no longer obscured. As the graphs show, the decrease continues as long as warm weather lasts in the autumn. When the weather becomes cold this decrease is arrested until early in May of the succeeding year. With the return of warm weather, the decrease is again clearly shown and becomes all the more striking as the temperature rises late in May and early in June. Probably the decrease in the population would be still more rapid with the occurrence of higher temperatures in midsummer, but any decrease at that time due to mortality cannot be distinguished from that resulting from the simultaneous emergence of adult beetles from the ground.

All reductions in population previous to the beginning of adult emergence must be a result of the various destructive agencies to which the insect is exposed in the ground in the course of its life cycle. In table 1 the population during the first half of June is indicated as averaging from 57 (7-year series) to 65 (4-year series) per cent of its maximum abundance the preceding September. It thus appears that a Japanese beetle population suffers a reduction from destructive agencies of from 35 to 43 per cent between the first part of September of one year and the middle of June of the succeeding year. Some of this destruction is doubtless caused by birds and other animals which feed upon the larvæ, but it is the view of the writer that by far the greater part is due to native soil-inhabiting microorganisms (pathogenic bacteria, fungi, protozoa, parasitic nematodes) originally infecting the immature stages of native Scarabæidæ and spreading thence to those of the introduced Japanese beetle.

Thus far there is no clear evidence that the introduced parasites of the Japanese beetle have played more than a minor rôle in bringing about the observed reductions in abundance of the insect. These reductions have been too general and wide spread to be attributable to the introduced parasites, which to date have been mostly confined to small areas in the immediate vicinity

of the points of liberation. However, the recent marked increase in their numbers at several of the stations where introductions have been made suggests that in the future these parasites are likely to play a far more important rôle in reducing Japanese beetle populations than they have up to this time. Although the outlook is as yet rather indefinite, developments in the parasite situation, although provokingly slow in reaching a decisive point, have in the past few years taken so promising a turn as to give good ground for optimism in the hope that the introduced parasites will furnish the key to the eventual control of the Japanese beetle. Realization of the potentialities in this direction, however, should not be permitted to blind one to the possibly indispensable, even if minor, rôle likely to be played by the less obtrusive organisms of native origin, which apparently have heretofore been mainly instrumental in effecting at least partial control of Japanese beetle populations.

COOPERATIVE SERIES OF SURVEYS

Since the seasonal series of surveys were confined to the vicinity of the original point of entry of the Japanese beetle into this country, the question naturally arises whether conditions similar to those just described would hold in other portions of its range. Information on this point was supplied from a series of cooperative surveys conducted between 1932 and 1934 in various pastures distributed through a heavily infested portion of Salem County, N. J. This section is situated from 25 to 40 miles from the original center of spread of the insect and did not become generally infested until 1929.

These surveys differed from those of the seasonal series in that they were not always conducted in the same group of stations. Consequently, the conclusions drawn in regard to the seasonal changes in population are based upon a consideration of all the available evidence and not exclusively upon that from any uniform set of pastures.

Inasmuch as no surveys have ever been conducted in Salem County during that part of the summer when egg deposition is most actively in progress, no data were available for charting the course of population change previous to its reaching its maximum

abundance early in the autumn (fig. 2). The only surveys made at a time in the year when the population was close to a maximum was a series conducted in 9 pastures from September 20 to 22, 1933. These gave at that time a common average of 14.0 larvæ per square foot. A resurvey of the same pastures from October 6 to 11 of the same year showed a common average of 10.1 larvæ to the square foot, a decrease of 28 per cent (fig. 2).

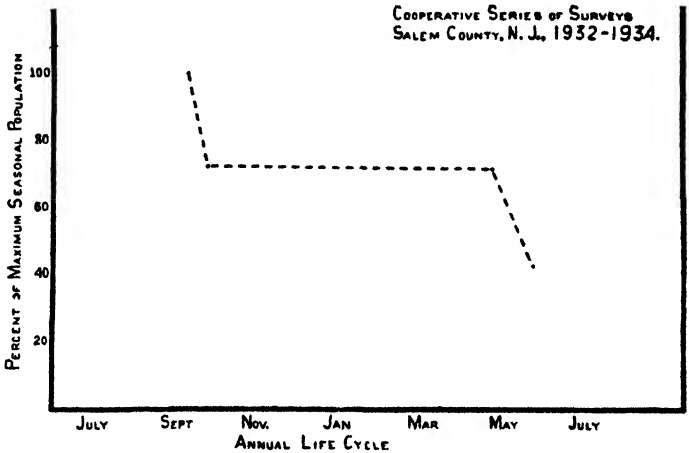


FIGURE 2.—Seasonal trends in relative abundance of Japanese beetle populations in the soil in percentages of the maximum average population in September, based upon records of the cooperative series of surveys for the period 1932–1934 in Salem County, N. J.

Records from a much larger number of pastures made it possible to compare populations found in Salem County during October with those occurring late in April and early in May of the succeeding year. A series of 20 pastures examined between October 18 and 28, 1932, and again between April 25 and May 4, 1933, yielded on the earlier occasion a common average of 11.5 and on the later one of 10.7 larvæ per square foot, a decrease of 7.0 per cent. Another series of 21 pastures (including most of those of the preceding group) examined October 2 to 11, 1933, and April 30 to May 11, 1934, gave for the earlier period a common average of 13.6 and for the later one of 14.6 larvæ per square foot, an increase of 7.4 per cent. The common average, + 0.2 per cent of the two sets of data thus accords fairly well with the evidences

of relatively insignificant winter decrease found in the seasonal series of surveys (*cf.* Figs. 1 and 2).

A comparison of the populations of pastures in Salem County early in May with the populations early in June is made possible by records from surveys made in 1933 and 1934. In the former year a series of 5 pastures, which about May 1 had yielded a common average of 22.1 larvæ per square foot, gave from June 5 to 8 an average of 10.5 larvæ and pupæ combined, a decrease in about 1 month of 52.5 per cent, while in 1934 a series of 4 pastures, which early in May had indicated a common average of 17.6, gave from June 4 to 6 an average of 12.4 larvæ per square foot, a decrease of 29.5 per cent. The average decrease from May to June for the 2 years was therefore 41.0 per cent (fig. 2).

By comparing these various results in relation to the maximum average population recorded in September, it is found that in October the decrease was 28 per cent, by the last of April or early in May the population remained essentially unchanged, while by the first part of June 57.5 per cent had been lost. Because they are based upon data from diverse sources, these figures can scarcely be regarded as more than very general approximations, but they show seasonal trends in Japanese beetle populations in the course of the annual life cycle that are in substantial accord with those indicated in the records of the seasonal series of surveys.

SUMMARY

Records of field surveys of the abundance of the soil-inhabiting population of the Japanese beetle conducted throughout the greater part of each year in a group of 8 stations, all situated within 12 miles of the original point of entry of the insect, and covering a total range of 7 consecutive years, reveal certain clearly defined trends in the course of its annual life cycle.

The general trends shown in Japanese beetle populations as regards relative abundance during the annual life cycle are consecutively as follows: (1) A rapid increase beginning late in June and extending through the summer, coincident with the season of active egg deposition, resulting in (2) the population reaching its maximum abundance early in September. This is followed by (3) a brief interval of rapid decrease lasting until

mid-October, (4) a long period of little or no apparent change extending through the winter and until about May 1 of the succeeding year, and (5) a second period of rapid decrease extending through May and into June, when adult emergence begins.

The absence of any significant winter reduction is attributed largely to the inhibitory effect of winter temperatures upon the activities of soil organisms parasitic or predatory upon the larvæ.

Rapid reductions in population are normally coincident with the occurrence of warm weather, and are therefore suggestive of biotic agencies as the cause. After June 15 the reduction is largely conditioned by the appearance of adults and their emergence from the ground, but previous to that date all reductions result from the various destructive agencies to which the immature stages of the insect are exposed in the soil, among which various native soil-dwelling organisms, parasitic or predatory upon the Japanese beetle, appear to play a major rôle, with birds and other surface-feeding animals playing a minor part.

Reductions in populations of the Japanese beetle due to its imported parasites have been too strictly local to figure as a significant factor in bringing about the general seasonal reductions recorded in this paper. More recent developments in the general parasite situation, however, hold much of promise as regards the eventual control of the Japanese beetle by the imported parasites.

The essential features in these changes in relative abundance of Japanese beetle populations throughout the annual cycle, which are primarily indicated in the records of continuous surveys in the older infested sections of the insect's range, are duplicated in the records of other surveys conducted in a more recently infested section in Salem County, N. J.

PRINCIPLES OF SCIENTIFIC PUBLICATION

Scientific investigators may be grouped under the following categories: (1) The independent worker, *i.e.*, the individual who devotes a part or all of his time to investigation, carrying on his researches with his own financial resources. On the basis of motivation, this group of workers may be further differentiated as: (a) the investigator who does his work for what he can discover of saleable value, (b) the investigator who works because his problem bears a certain degree of fascination or interest, (c) the investigator who carries on because he is convinced that his investigation will benefit and advance the race (medical). (2) The salaried worker. This group also may be divided into: (a) the government, medical and museum investigator (with ideals of b and c, above), (b) the industrial investigator.

The person who is hired by the government, museums, or business is being paid to investigate. Nothing is said about publication. That is always an entirely separate matter. A business concern pays such an incumbent to carry on investigations, *not* to publish any findings. Museums usually maintain a Journal for publication of results, as also some research institutions, and the government. If a research hospital or institute wishes to become renowned through the high quality of its research it should be willing to pay for the publicity. The investigator who works to satisfy his curiosity or his desire for knowledge concerning a phenomenon of nature is under no more obligation to publish than is the man who discovers a new move in chess, or a new way of applying pigment to canvas—especially when he himself bears the expense of the investigation. Since when is a person under obligation to publish the fruits of his hobby? If Society wishes to benefit by the investigations of the men who voluntarily go through hours, days and months of drudgery and grind in order to discover a truth or principle of nature, Society should be willing to pay for the publication of his findings. After all, life, like marriage, should be a coöperative enterprise, and to expect or compel the investigator to shoulder the

burden of publication, in addition to the drudgery and cost of the investigation, is not only short-sighted but lacking in social sensibility and a sense of justice.

Publication is not a part of research. Research terminates when the investigator has discovered that for which he is seeking. If Society or the investigator's institution wishes, for reasons of its own, to know the result of any investigation, it should be willing to shoulder the burden of publication.

A recent article,[1] purporting to be a contribution on the publication problem, breaks down completely because its author fails to analyze his data, and because he fails to take more factors into consideration. In the fifth paragraph of that article, only the salaried investigator seems to be considered. The paragraph is not even clear as to who "rends the air with cries of anguish," the investigator or his institution. Certainly it should not be the worker. If the institution, what? Museums and government investigations are supported by the public. Is it the museum, or the public, or the government official which is rending the air? If the public hires research workers through museums, hospitals, or experiment stations to carry on investigations, should not the public pay for publication of the results? If the investigator is hired by an endowed research institution, that institution may publish or not as it sees fit (and they usually do). Why should it publish? Did the benefactor stipulate that the money should be used for publication? If Society desires the benefit of the investigations should it not be willing to pay for the publication?

There is no relation between research and publication, except in so far as Society desires the benefits of research. This applies especially to the independent investigator and independent research institutions. Society should be so organized that through endowments, the results of investigations may automatically be published. In fact Society should be so organized as to be able to adequately hire all capable investigators.

This brings us to the old question of what constitutes publication. There has been a tendency in recent years to shirk responsibility of publishing so-called "raw data."

All data should be published. One of the fundamental characteristics of scientific work is that it is so conducted that it may

[1] Science, 84: 310–311, October 3, 1936.

be repeated or checked up—gone over by others as often as necessary and with whatever variations may be deemed advisable. This presupposes publication of all data and methods. Data unpublished is data lost. The structure built on this lost data is a structure without visible or substantial foundations. The next architect is unable to examine the foundations of the edifice. He must then go through the arduous and time consuming process of accumulating another set of data in order to check up on the stability of the superstructure. The supression of raw data hamstrings discussion and criticism, one of the fundamental characteristics of science. I can well perceive how delighted pseudo-scientists would be to place their "discoveries" beyond the pale of criticism and discussion by the suspension of their raw data.

The filing of "raw data" in the institution's morgue is unsatisfactory to any worker separated by an ocean or even a continent. It will cost him as much to go to the data as it would cost to have the data published. To have the data sent him will entail risk of loss. The same expense and hazard is repeated with the second, the third, and other reviewers or checkers. Inevitable wars jeopardize such filed data. So does a change in department head, or future shortage of space. We have recently witnessed the junking of years of accumulated material by a new museum president who did not fancy a certain line of investigation. Publication makes data virtually indestructible and makes it available on all continents and in all culture centers. It is the obligation of organized Society to make such data available to its underpaid investigators in all countries. In the long run, it is more economical to pay for such publication. Society's obligation is to endow scientific publications, as well as museums, hospitals, university buildings, bell towers, and dog cemeteries.

ARTHUR PAUL JACOT

The Microscope. By Simon Henry Gage, Emeritus Professor of Histology and Embryology in Cornell University. 16th Ed. rev. and enlarged, 617 pp., illus., bibliog., Ithaca, N. Y., Comstock Pub. Co., 1936. $4.00.

Since the 15th edition (1932) of this work was reviewed in the JOURNAL of the New York Entomological Society (40: 389–390), it seems fitting that notice also should be given herein of this newly issued 16th edition. Most gratifying advances are being made every year in microscopical knowledge so it is desirable to add, from time to time, a portion at least of the outstanding improvements in successive editions of this work. In this edition, therefore, have been added the simplified means of reflecting ultra-violet radiation by mirrors coated with aluminum by the vapor method, which promises much for the future of optics and astronomy. There has been included also a chapter on micro-incineration with its possibilities for giving definite information concerning the presence, amount and location of the fixed mineral salts in the tissues and cells of the body.

All the well known features of previous editions which have proved of widest usefulness have been retained and where necessary have been amplified. These include treatment of such topics as lighting, natural and artificial; dark field microscopy and its application; micro and pocket spectroscope; interpretation of appearances; magnification and micrometry; drawing with the microscope and with projection apparatus; photographing and enlargements; cabinets, slip and cover glasses; mounting, labeling and storing microscopical preparations; fixing and preservation of tissues, organs and organisms; infiltrating, imbedding, sectioning, and staining and mounting for the microscope. There are also given a brief history of lenses and microscopes and a comprehensive bibliography of the entire subject. J. S. W.

A NEW "SILVER-MARKED" EUCOSMA (LEPIDOPTERA—OLETHREUTINÆ)

BY WM. T. M. FORBES
CORNELL UNIVERSITY, ITHACA, N. Y.

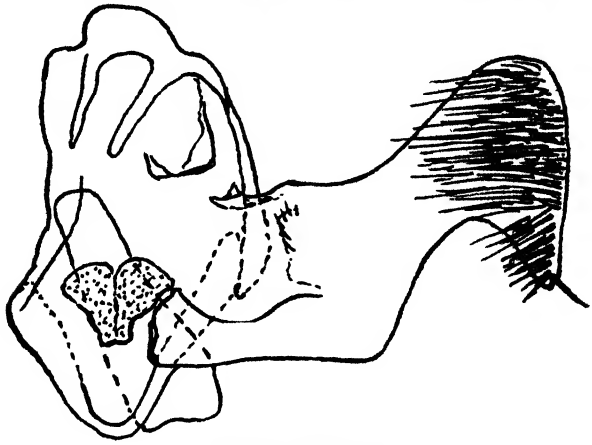
It has reached the point when new species of Lepidoptera outside of a few critical groups are beginning to be rare from New York. The following is the most striking that has been through my hands for some time, and has no very close relative in the eastern states. The capture of seven specimens in two seasons gives hope that it may turn out fairly common.

Eucosma lathami, new species

General structures of typical Eucosma; fore wing with M_3 and Cu, closely approximate at margin, and M_2 somewhat; apex produced and outer margin oblique and somewhat concave; hind wing with M_3 and Cu_1 rather long-stalked.

Pure white (not really silvery) and fuscous brown. Head and thorax white (unlike the other silver marked species from the east, but like *morrisoni* and *bolanderana*), the outer ⅔ of antennæ, outer side of palpi, tips of tegulæ and abdomen tinted with pale gray-brown. Anal tuft pure white. Fore wing brown, marked with pure white;—a white costal stripe, in the male starting below the brown costal fold, narrower just before middle, then widened and containing brown pm. and st. dots and tapering to a point at apex; in female running along costal edge toward base, with a brown subcostal stripe and another white stripe below that representing the base of the male costal stripe, but cut off from its outer portion. Median stripe in male forking off from the costal one at ⅓, in female continuous with the second stripe at base, but leaving the part corresponding to the costal stripe of male as a short subcostal spur,—then in both sexes of almost even width to middle of outer margin; cut by an oblique spot or bar at lower angle of cell; three white stripes below this, the first lying on the anal convexity, and extending from just beyond base to ⅔, the second along inner margin from ⅛ to ½ and the third along basal lobe of inner margin. The first two of these stripes connect in male to form an offset stripe, and the one female has an additional small spot beyond the tip of the first, cut off from the median stripe by the brown fold only. Base of fringe powdery gray, outer ½ light fuscous, like hind wing. Hind wing light fuscous, the base of fringe hardly paler, but outer ½ whitish. 16 mm.

This species is closest to *E. morrisoni*, as shown by the stripe of dark ground below the median stripe centering on the fold, the powdery fringe and the anal spine on the genitalia (see figure); but is distinct in the dark brown ground and many details. The genitalia are about as in *morrisoni*, but the terminal edge of the valve is straighter. In Heinrich's key (Bull. U. S. Nat. Mus. 123: 74) the species will run to alternative 30, but differs in the white head and thorax, and deeper duller brown ground; in mine (Lep. N. Y. 417) it runs to alternative 5, and separates in the same way.



Eucosma lathami

Orient, Long Id., New York. Holotype June 18, 1935, paratypes June 8, 10, July 11, Aug. 8, 12. The types will be divided between the U. S. National Museum, Cornell University and Mr. Latham's collection. The larva is certainly a borer, and is to be expected in Compositæ.

A CYPHOPHTHALMID FROM SOUTH AMERICA. (ARACHNIDA, PHALANGIDA)

BY NORMAN W. DAVIS

This is the third species of the suborder to be found in the Western Hemisphere and the first from South America. The material was received by Dr. Arthur Jacot in collections from August E. Miller. Dr. Jacot very kindly turned this material over to me.

Unfortunately the vial containing these specimens was labeled only "Kartabo, Bartica District, British Guiana." No additional data have been obtained. In view of the scarcity of these animals it was decided to publish in spite of the deficiency.

Siro kartabo new species

MALE. Length 2.8 mm.

Lengths of segments of appendages in millimeters:

Chelicera, I 1, II 1.4, III .24, total length 2.6.

	tro-chanter	femur	patella	tibia	meta-tarsus	tarsus	claw	total
Palpus	.42	.49	.32	.42		.39	.06	2.10
Leg I	.35	.91	.56	.70	.42	.70	?	?
Leg II	.32	.81	.42	.56	.35	.56	.14	3.16
Leg III	.28	.70	.35	.42	.28	.53	.18	2.74
Leg IV	.35	.81	.46	.56	.42	.56	.18	3.34

Dorsum with anterior median protrusion formed by two nearly vertical plates connected dorsally by a transverse ridge. Dorsum otherwise rounded anteriorly.

Eyes lacking. Stink-gland tubercles approximately as high as their basal diameter, tapering distally, and set at a distance very slightly less than their basal diameter from the lateral margin of the carapace. Apical nodules of stink-gland tubercles large and prominent. Posterior thoracic suture present arching caudally across the carapace from between the third and fourth coxæ.

Maxillary lobe of coxa I extending about one-third of the total length of the coxa. A short row of hairs beside this lobe. Maxillary lobe of coxa II very large, broader than long, deeply constricted caudally. Apparently coxæ

I and II are movable and coxæ III and IV are fixed. Coxa IV wider than coxa I; coxa I wider than coxa III; coxa III slightly wider than coxa II.

Genital opening elliptical, nearly circular, unarmed. Each spiracle enclosed on the inner and caudal sides by the lateral suture.

Eighth and ninth sternites and ninth tergite fused into a single plate which surrounds the anal operculum. This plate with small lateral indentations in the anterior margin. Anal operculum with slight lateral depressions.

First segment of chelicera laterally compressed. Dorsal and lateral surfaces rounded, mesal and ventral surfaces flattened. Dorsal surface as seen from side with a deep depression into which fits the anterior-median protrusion of the carapace. Just anterior to this a prominent retrorse pointed eminence which appears as a transverse ridge in dorsal view. Anterior to this ridge the dorsal margin curves slightly dorsad and is armed with several small hairs and a few minute tubercles. Ventral margin as seen from the lateral side constricted near base then abruptly expanded forming a conical eminence, anterior to this the surface is slightly concave and armed with scattered small hairs and minute tubercles. Second segment tapered distally to a point just proxad of the chelate portion and then expanded slightly, roughly circular in cross-section, chelate portion armed with three denticles. Third segment slender, unarmed, circular in cross-section.

Trochanter of palpus curved dorsally, incrassate distally, armed with a very few hairs ventrally. Femur straight, cylindrical, armed with a few hairs. Patella curved slightly ventrad proximally, expanded distally. Tibia nearly straight. Tarsus fusiform, straight, terminating in a short straight claw.

Legs granulated and garnished with a few hairs which are more numerous on tarsi than on other segments. Claw of leg I smooth. Claw of leg II armed on ventral side with a row of five or six small close-set denticles and on the posterior side with two tubercles. Claw of leg III armed on the anterior side with two tubercles and on the posterior side with two tubercles. Claw of leg IV strongly curved, armed with two tubercles on the anterior side and two tubercles on the posterior side. Dorsal eminence of tarsus IV consists of a rounded basal part from which a group of small bristles projects.

Body dark reddish brown. Appendages slightly lighter in color.

FEMALE. Similar to male but differing in the following respects: metatarsus IV and tarsus IV much smaller in diameter than those of male; dorsal eminence lacking on tarsus IV.

Holotype male, allotype female, paratype male. Kartabo, Bartica District, British Guiana. Cornell University collection.

A Manual of Entomological Equipment and Methods. Part II. By Alvah Peterson. John S. Swift Co., Inc., St. Louis, Chicago, New York, Indianapolis. 334 p. inc. 21 pl. 1937. $4.50 plus postage.

It is a pleasure to record the publication of Part II of Dr. Peterson's "Manual of Entomological Equipment and Methods." The first part was reviewed in the March, 1935 issue of this JOURNAL. The second part presents abstracts and original contributions on rearing information, together with abstracts of papers dealing with the transportation of living and pinned insects, the marking, and collecting of insects, insect photography, sampling, mounting, trapping, inflating, staining, museum and laboratory methods, etc., all highly useful and important to all kinds of entomologists and exceedingly convenient to have between two covers.

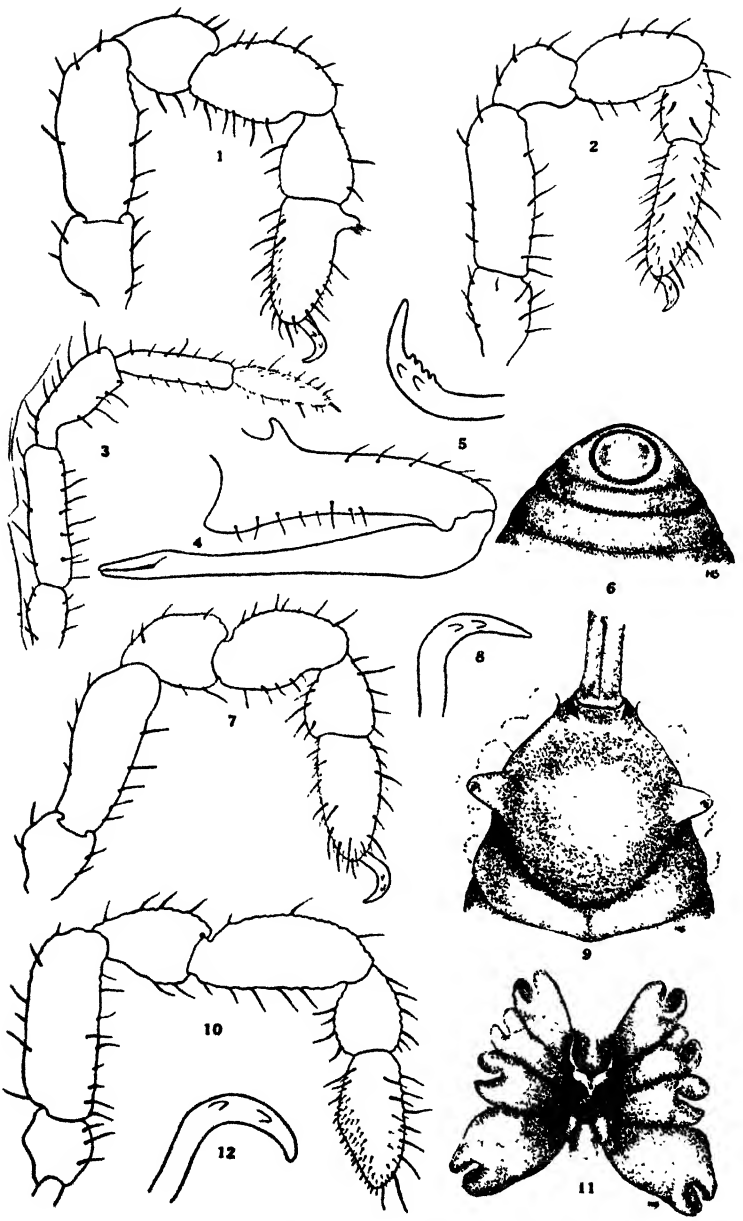
Approximately 1125 abstracts are arranged alphabetically by authors; ten plates illustrate cages for rearing insects, parasites, wood borers, for oviposition studies, etc.; seven plates deal with feeding, counting, collecting, and with museum equipment, and four plates with transportation, liberation and miscellaneous equipment. Adequate indexes make it easy to locate special interests. Dr. Peterson's book is a planographed production, in a substantial blue cloth binding, with gold lettering. Its text touches every phase of entomology, and it is a much needed work. It is hoped that it will be adequately supported so that its author will be encouraged to issue supplements when necessary.

H. B. W.

PLATE I

Siro kartabo, male

Figure 1. Fourth leg, right.
Figure 2. Second leg, right.
Figure 3. Palpus, right.
Figure 4. Chelicera, right.
Figure 5. Second tarsal claw.
Figure 6. Anal operculum and posterior sternites.
Figure 7. Third leg, right.
Figure 8. Fourth tarsal claw.
Figure 9. Cephalothorax, dorsal view.
Figure 10. First leg, right.
Figure 11. Cephalothorax, ventral view.
Figure 12. Third tarsal claw.



SIRO KARTABO

General Entomology. By Robert A. Wardle, professor of Zoölogy, University of Manitoba, Winnipeg, Canada. 8vo., washable cloth, 311 pp., 96 illus. Philadelphia, P. Blakiston's Son and Company, 1936. $2.25.

This is not "just another book," since it proves to be a work that is well worthy of the attention of the working entomologist because the author has emphasized a broad appreciation of the basic principles of the subject. Beginning with such matters as external and internal anatomy, development and life cycle, the discussion continues into physiology and behavior, and later into Proturoid and Palaeopteroid, Orthopteroid and Plecopteroid, Zygopteroid and Ephemeropteroid insects. These are followed by similar treatment of Hemipteroid, Panorpoid, Coleopteroid, and Hymenopteroid insects. Though not elementary in character, the book is intended for the use of the general student of entomology rather than the specialist who would require detailed knowledge of such ramifications as insect morphology, insect classification and the like. A considerable number of illustrations in proportion to the size of the book have been included; some have been borrowed from other works, with suitable adaptations, and many have been specially prepared for this work. Use also has been freely made of subject material and illustration from pioneer workers, as well as such from recent monographic studies. Living specialists in various fields of activity have been designated by name and in numerous instances résumés of important work by them have been included. This feature alone is certain to add much to the general usefulness of the book, particularly to entomological workers isolated in locations remote from centers of contact with professional colleagues. J. S. W.

AN OLIGONEURID FROM NORTH AMERICA*

BY HERMAN T. SPIETH
COLLEGE OF THE CITY OF NEW YORK

Despite the many serious and wholly justifiable objections to describing a single specimen, I am following such a procedure for these reasons: (1) The specimen under consideration is obviously a member of an exotic family about which our information is meager, and this is the first record of the family from North America; (2) the collecting methods employed give a clue as to why the nymphs of this species have not been taken previously.

The specimen is an almost mature male nymph and was collected from the White River at Decker, Indiana, on July 27, 1932, by Stacey Denham, who kindly forwarded it to me. Its description is as follows:

Length, including tails, 12.5 mm.; exclusive of tails, 10 mm. Head roughly semi-globose with the mouth parts projecting posterio-ventrally; compound eyes huge, occupying most of the area of the head, and contiguous along the mid-line, thus completely eliminating vertex except for a small area anteriorly. Nymphal eyes undivided; those of the adult as seen through the thin chitin show no indication of being divided. Lateral ocelli wedged between the antennæ and compound eyes, being displaced so that they are anterior and ventral to the median ocellus which lies in an angle formed by anterior margins of eyes. Fronto-clypeal area greatly reduced; along edge of this area and the ventral edge of the parietal areas a fairly dense fringe of short setæ. Antennæ twelve-jointed, short and stubby; scape short and heavy; pedicel almost as heavy and much longer, comprising a third of the total length of the antennæ; remaining segments subequal and gradually decreasing in diameter toward the tip.

Mouth parts typically oligoneurid; labrum (Fig. 10) uniformly pilose over the anterior surface; mandibles (Fig. 5) with a large, well developed molar area, and reduced, smallish incisors,

* The author takes this opportunity to express his appreciation to Mr. Stacey Denham for the specimen considered in this paper, and to the American Museum of Natural History and especially Dr. F. E. Lutz for providing space in which to conduct research.

the outer one having three small teeth at tip and the inner one appearing like a huge, sharp-pointed seta; the lacina mobilis as long as outer incisor; maxillæ (Fig. 1) with semi-lanceolate galea-lacinia; palps two-jointed; basal segment short and the distal one long, large, curved and finger-like; at the base of maxillæ a large tuft of respiratory filaments as in *Isonychia;* labium (Fig. 4) heavily pilose; glossæ small and lying dorsal to the larger paraglossæ; palps two-jointed, the second large and broadly expanded.

Thorax short and compact; the anterior and posterior margins of the pronotum straight and parallel. An extension of the posterio-lateral area of the pronotum extending as a broad lobe-like projection posterior to the prothoracic leg (Fig. 9). Wing pads large, thick, and blackish as in all nymphs just before emergence; the metathoracic wings of the adult apparently good-sized.

Legs (Figs. 7, 8, 9) peculiar in that the coxæ and trochanters of the meso- and metathoracic legs are very long and robust. Coxa of fore-leg about three-fourths as long as femur; trochanter small; tibia forming a flat blade-like structure about one and one-half times the length of femur and ending in a blunt semi-hook, on the outer side of which is a small unsegmented papilla-like structure which represents the tarsus; inner side of basal half of femur and middle three-fourths of tibia bearing extremely long slender setæ which are secondarily dissected; a patch of long slender setæ on inner surface of coxa; outer surface of coxa, trochanter and femur sparsely setose. Coxa of second leg subequal to femur, longer than any other part and covered with setæ on outer surface; trochanter robust and longer than tibia or tarsus, and expanded and rounded on medio-ventral surface, this surface being covered with long robust setæ; femur covered with robust setæ; tarsus subequal to tibia and both sparsely covered with short setæ; tarsus ending in a single slender claw. Coxa of hind leg heavy and long, representing one-third of entire length of leg, and fairly densely covered by long slender setæ; short, semi-globose trochanter covered with long slender setæ on ventral surface; femur, tibia, and tarsus, which decrease in length and robustness in order named, clothed with long, heavy setæ; tarsus tipped by long slender claw. Adult

legs as seen through the nymphal chitin appearing very slender and weak.

Abdomen long, slender, and cylindrical; segments gradually increasing in length and decreasing in diameter from first to ninth inclusive; tenth segment considerably smaller than any other; tergites uniformly covered with short, stubby setæ; on anterior sternites setæ much denser, longer, and finer than on corresponding tergites, with a gradual reduction in density and length of setæ on more posterior sternites until ninth sternite matches ninth tergite; in addition a distinct fringe on posterior edge of all sternites due to increased density and length of setæ. Through the thin nymphal chitin, it can be seen that the adult would have a broad dark, irregular band on its posterior edge of each abdominal tergite increasing in width posteriorly until that of the ninth segment would occupy almost half of the tergite; no indications of posterio-lateral spines on segments 1 to 7 inclusive; lateral spines on segments 8 and 9 short, not extending beyond posterior margin of their respective segments.

Gills present on abdominal segments 1 to 7 inclusive; last six (Figs. 2, 3) consist of single, slender, flat, plate-like structures which extend posterio-laterally from posterior angle of each segment, apparently none having any tracheæ; first gill (Fig. 11) a huge, highly dissected plate-like structure that has migrated and rotated so that it extends ventrally and parallel to the longitudinal axis of the body and lies between the posterior pair of legs. It is completely invisible from a dorsal view and when first seen seems to arise from the thorax; also there is a median, finger-like, posteriorly directed process from posterior edge of first sternite.

Nymphal genital apparatus appearing as a truncate cone with a concave top surface. It is impossible to determine what the adult genitalia would be like. Three subequal caudal tails; lateral ones having a dense fringe of long, slender setæ on inner side and a similar fringe on both sides of middle tail; laterals with 25 segments, the middle tail 22.

It is possible from the structure of the nymph to determine something about its ecology. The long, slender, cylindrical shape eliminates the possibility of its living under stones, etc., as *Hep-*

tagenia and its relatives do. The lack of digging apparatus indicates it is not a burrower. The immaculate condition of the specimen shows it not to be a sprawler like *Cœnis*, or a clamberer like certain *Ephemerella*, and the peculiar build of the gills, especially the huge first gill, eliminates the chance of its being a swimmer amongst the vegetation such as *Callibœtis* and to some extent *Siphlonurus*. Superficially the specimen looks like *Isonychia*. Inspection of the first leg and mouth parts confirms the notion that this species probably lives and feeds much like *Isonychia, i.e.,* it lives on the bottom in a place where the current is fairly rapid and, by facing the current, it is able to sift out its food with the long setæ that are found on the front legs. There are, however, certain obvious and striking differences between *Isonychia* and this specimen: (1) In the relative proportion of the various parts of the legs, as well as their disposition in relation to the rest of the body; (2) in the arrangement of the gills: in *Isonychia* all seven pairs are quite similar in structure and location, while in this species the task of respiration is taken over mainly by the first pair which is carefully protected between the metathoracic legs. It is necessary to consider these structures further in order to comprehend how the nymph lives.

The coxæ all extend directly downwards and the fore-coxæ are less than half the length of the meso- and metacoxæ. The fore-leg (Fig. 9) is held somewhat like the arm of a boxer when he fends off a blow that is directed toward his face. From the mesocoxæ the trochanter and femur extend outward and upward while the tibia and tarsi continue outward and downward so that the rounded setose inner surface of the trochanter and the end of the tarsus are all that come in contact with the substratum. From the metacoxæ the remainder of the leg extends at a right angle straight backwards and parallel to the longitudinal axis of the body so that the anterior surfaces of the trochanter, femur, tibia and tarsus come into contact with the substratum. Thus the body of the nymph and also the first pair of gills which are located ventrally are held away from the substratum by the long meso- and metacoxæ, while the outwardly extended mesothoracic legs keep the specimen from rolling sidewise and the posteriorly directed metathoracic legs keep the nymph on a level keel facing

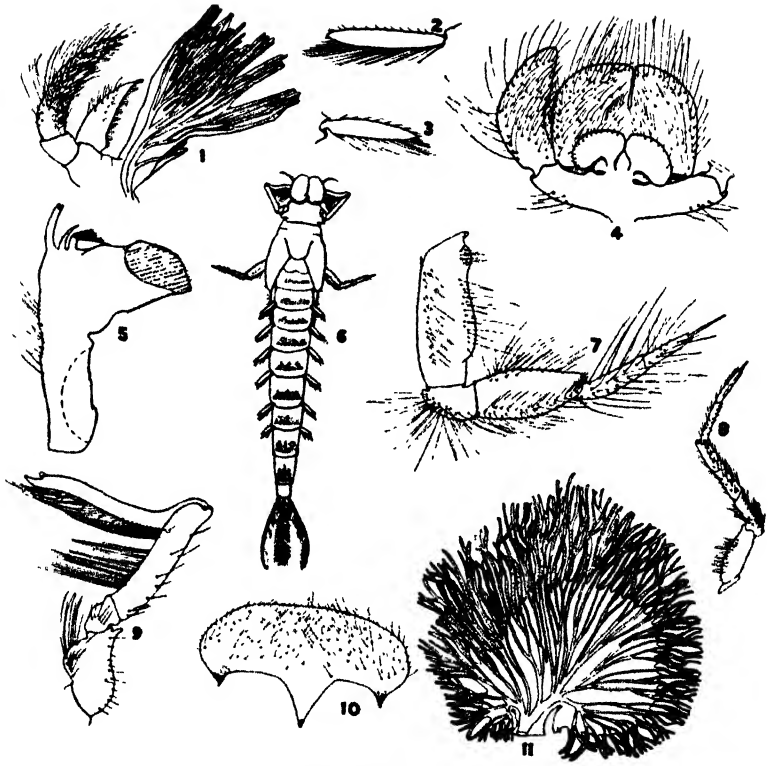
into the current. Since the fore-coxæ are short, the fore-leg moves freely in the area between the substratum and the body, and the long hairs filter the water, thus insuring food for the nymph and simultaneously insuring filtered water for the first gill. This condition, plus the fact that the main part of respiration has been taken over by this protected gill, indicates that the nymph lives in an environment where there are a great many small particles in suspension. This is in accord with the statement of Mr. Denham that the substratum upon which this specimen lived was sandy. When we know more about this species, I think we will find that the nymph lives in sandy streams, probably at the riffle end of sand bars.

Phylogenetically the nymph shows no relation to *Isonychia*. A comparison of the general shape, gills, legs—especially the first leg—, and mouth parts with those of the nymph of *Oligoneuriella*, *Elassoneuria*, and *Noya* indicates without a doubt that it is a member of the family Oligoneuridæ. The type of this family is *Oligoneuria anomala* from Brazil, the nymph of which is unknown. Very closely related is *Oligoneuriella rhenana* of Europe. The nymph of *O. rhenana*, which is well known, shows a decided resemblance to the specimen described above. There is, however, in Central America the genus *Homeoneuria* which is also known from adult specimens only. In view of these facts, I am refraining from giving this specimen any name. The close similarity of the nymph to that of *Oligoneuriella* indicates that it may be a member of the genus *Oligoneuria*, since the adults of these two genera are closely related.

Why has this species never been collected before? The method of capture gives a clue. The specimen was taken from the deeper waters of a sandy river by means of a Peterson dredge. Most collections of mayfly nymphs are made in small streams, ponds, etc., and along the edges of larger bodies such as lakes and rivers. Those species that are peculiar to the deeper waters of lakes and especially of rivers are still poorly known. The adult of this species probably emerges, mates, deposits its eggs, and dies all in a single night. This is somewhat confirmed by the fact that the adult legs would probably be very weak, if not almost functionless as is the case with *Campsurus* and *Ephoron*. Unlike these, however, the adult of this specimen is probably negatively phototropic.

PLATE II

Figure 1. Right maxilla. × 64.
Figure 2. Second gill. × 60.
Figure 3. Seventh gill. × 60.
Figure 4. Labium. × 64.
Figure 5. Right mandible. × 130.
Figure 6. Dorsal view of nymph. × 12.
Figure 7. Metathoracic leg. × 50.
Figure 8. Mesothoracic leg. × 21.
Figure 9. Prothoracic leg. × 50.
Figure 10. Labrum. × 130.
Figure 11. First gill. × 21.



OLIGONEURIDÆ

BOOK REVIEWS

Forest Insects: A Textbook for the Use of Students in Forest Schools, Colleges, and Universities, and for Forest Workers. By R. W. Doane, Professor of Biology, Stanford University; E. C. VanDyke, Professor of Entomolgy, University of California; W. J. Chamberlin, Professor of Forest Entomology, Oregon State College, and H. E. Burke, formerly Senior Entomologist, U. S. Department of Agriculture. First ed., 8vo., cloth, 463 pp., 234 illus. N. Y. McGraw-Hill Book Co., 1936. $4.50.

The comments on this book which follow are made from the viewpoint of a student of Coleoptera, not of a specialist in forest entomology. Since 217 of the 463 pages of the volume are devoted to consideration of insects of that order, the work will have a special appeal to all who may be concerned with their study. The various topics treated include such as life history and control of bark beetles, ambrosia beetles, and flathead and roundhead borers, with discussion in some detail of surveys of infested areas, analysis of such surveys, conditions necessary to successful control, preventive methods, treatment after attack, character of host plants, and the like. Considerable attention has been given to such matters as insect distribution and classification, as well as to the study of various ecological factors bearing on species attacking coniferous twig, cone, and broadleaf trees. Due consideration also has been given to control of other beetles attacking forest trees, notably, such as predaceous ground beetles, rove beetles, lady beetles, cylindrical bark beetles, cucujids, skin beetles, steel or hister beetles, sap-feeding beetles, ostomids, snapping or click beetles, cross-wood borers, fireflies and soldier beetles, checkered beetles, powder post beetles, ptinids, death watch beetles, bostrichids, true powder beetles, darkling beetles, melandryids, pythids, oedermerids, mordellids, pyrochroids, blister beetles, May beetles, stag beetles, leaf eating beetles, flea beetles, tortoise beetles, and various weevils.

The book as a whole has been so prepared that it will be useful in the field as well as in the laboratory and classroom, and there

are also chapters on forest tree pests in other orders of insects, notably the moths and butterflies, sawflies, horn tails, bees, ants, aphids, scale insects, termites, and others. Lists of the more important forest trees and their principal insect enemies are included, and control methods for each order of insects are given. The subject matter purposely has been couched in non-technical language so as to be of wider usefulness to the forest ranger and the beginner in forestry, while the very full bibliographies at the end of each chapter will be particularly helpful to special students who may wish to make a more detailed survey of various insect groups. J. S. W.

THE ELUSIVE JOHN THORLEY, AUTHOR OF "MELISSELOGIA, OR THE FEMALE MONARCHY"

One hundred and thirty-five years after the publication at Oxford of Charles Butler's first edition of "The Feminine Monarchie, or The Histori of Bees," there appeared "Melisselogia, or the Female Monarchy, Being an Enquiry into the Nature, Order and Government of Bees, . . ." by the Reverend Mr. John Thorley, of Oxon. Mr. Thorley's book was printed in London, 1744, "for the author" and sold by N. Thorley, probably a relative, and by J. Davidson.

Like Butler, Thorley was a minister, as well as a beekeeper, but Thorley's book, although practical and correct for his time, is not now so quaint and amusing as Butler's "Feminine Monarchie" which reached a third edition and included such mythical accounts as bees building an altar in a hive, around a consecrated host.

Thorley had 459 subscribers for his book, including 43 ministers, and as many of them subscribed for several copies, and one for 100, the total number of subscriptions amounted to 784.

Almost nothing seems to be on record concerning Thorley's life. He lived at Chipping Norton, in the County of Oxford, when he published his book, and by 1743 he had behind him forty years of experience as a practical beekeeper. He was married, because on page 164 of his book he mentions his little daughter. He also had a maidservant and he was opposed to drinking and did not describe the making of mead and metheglin, as did Butler, 135 years previously. As would be expected, in view of his calling, his book is interspersed with references to divine wisdom, and because of his praise of King George and of the fact that he utilized every opportunity to urge "Britons and Hibernians" to be loyal, we may conclude that he was a faithful subject of the king.

According to the Bodleian Library, although he is described as "of Oxford," he was not a member of the University and did not hold a living or curacy in any Oxford church. In addition, the City Librarian of Oxford was unable to trace any biographical particulars about him. And so for the present at least, apart from his authorship of Melisselogia, details of his life are still missing.

H. B. W.

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INSECT DEVELOPMENT ANALYZED BY EXPERIMENTAL METHODS: A REVIEW

PART II. LARVAL AND PUPAL STAGES[1]

BY A. GLENN RICHARDS, JR.

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[1] This paper was prepared in the biological laboratories of the University of Rochester and Cornell University.

I. INTRODUCTION

Following the recent physiological reviews of Wigglesworth (1934a) and Hoskins & Craig (1935) it may seem surprising that another should be written so soon. This paper is an attempt to supplement these reviews by analyzing data from the point of view of the embryologist. Most of the subjects discussed are mentioned only briefly or even not at all in these other reviews; some subjects, of necessity, are treated again but from the embryologist's viewpoint rather than that of physiology *sensu strictu*. The origin of the germ cells and the differentiation of the gut have already been treated in Part I. Nutrition and metabolism are covered by Uvarov (1928), Needham (1929), Wigglesworth (1934a) and Hoskins & Craig (1935); effect of climatic factors by Uvarov (1931) and Imms (1932); heterogony and growth-gradients by Huxley (1932); wing-production and physiological races by Hoskins & Craig (1935); and the developmental aspects of genes by Goldschmidt (1932), Cohen-Kysper (1933), Morgan (1934) and Zawadowsky (1935). None of these topics will be repeated here.

This paper attempts to analyze from the embryologist's viewpoint the rôle of hormones in development, the possibility of a differentiation center in later insect development similar to that demonstrated in the early stages of ontogeny, the available data on organ development after the segregation of their presumptive anlagen, the voluminous data on insect regeneration, the possibility of organ development and regeneration representing gradient-field phenomena, and, finally, the phenomenon of diapause or cellular-dormancy.

The diverse appearances of the development of different insects has led to several attempts to correlate the facts of insect metamorphosis. The hypothesis here accepted as most satisfactory was proposed by Berlese in 1913 and is comprehensively treated by Imms (1931). According to the classification based on this hypothesis, post-gastrulation development of insects may be divided into three periods: (1) The *protopod* stage at which the embryo is incompletely differentiated as a whole both internally and externally. The head and thorax are segmented and bear rudimentary appendages but the abdomen lacks appendages

and is poorly or not at all segmented. (2) The *polypod* stage in which the abdomen has become completely segmented, each segment bearing rudimentary appendages, the tracheal invaginations have begun and the internal organs are well defined. And (3) the *oligopod* stage in which final differentiation takes place, the cephalic and thoracic appendages attain their definitive form, the tracheal system becomes completed and the abdominal appendages resorbed except such as are to be retained by the adult (cerci and genitalia). These three stages can be recognized with varying degrees of distinctness in the various insect groups but the point of interest is that *they are not all invariably passed within the egg.*

According to this hypothesis the hemimetabolous insects pass through all three stages within the egg and emerge in a post-oligopod stage termed a nymph, whereas the holometabolous insects emerge at an earlier stage, sometimes in the protopod stage as veritable embryos (*e.g.* primary larvæ of endoparasitic Hymenoptera), sometimes in the polypod stage (*e.g.* lepidopterous caterpillars), sometimes in the oligopod stage (*e.g.* campodeiform larvæ of Coleoptera and Neuroptera), and sometimes in a degenerate oligopod stage which is apodous (*e.g.* dipterous larvæ). In the Hemimetabola, then, the nymphal instars are preparatory to the development of the adult, but in the Holometabola the larval instars are preparatory to the development of the pupal instar which is the ontogenetic counterpart of the nymphal instars of the Hemimetabola.

Although Berlese's three hypothetical embryonic stages seemingly rest on an environmental or rather nutritional basis for time of emergence from the egg, and so only indirectly affect the topic of this paper, they illustrate the undesirability and practical impossibility of satisfactorily separating development within the egg from development after emergence from the egg. Indeed, most of the experimental work which has produced satisfactory results has dealt with the pre-protopod stages within the egg, and the polypod and oligopod stages after emergence from the egg. From the developmental viewpoint this represents a continuous physiological process.

II. EXPERIMENTAL MATERIALS AND METHODS

The forms experimented upon include representatives of all the major orders and several of the minor orders. The majority of the papers cited are based on amputation and transplantation and the modification of environmental factors; genetic analyses and constrictions are next in importance. Comparison with the techniques used on embryos (Part I) shows a marked difference in the relative values of the various methods, partly due to the lack of any satisfactory technique for the transplantation of egg-parts. [References in italics give methods in detail.]

1. **Amputation and transplantation** of body components to determine the effect on (a) the donor, (b) the host, and (c) the graft [Meisenheimer 1908 ff., *Kopeć 1918* ff., Bodenstein 1930 ff., Caspari 1933, *Wigglesworth 1934c*, *Ephrussi & Beadle 1937* and numerous other workers on various insects].

2. **Constriction** of larvæ and pupæ [Urech 1897, *Hacklow 1931* and Caspari & Plagge 1935 (Lepidoptera), and *Fraenkel 1935* (*Calliphora*, a fly)].

3. **Injection of blood** of one stage or sex into another [Kopeć 1911, Umeya 1926 and Buddenbrock 1930b (moths), and Fraenkel 1935 (*Calliphora*)].

4. **Formation of parabiotic twins** by (a) grafting together pupæ and pupal parts [*Crampton 1899* (Lepidoptera)]; (b) grafting together nymphs [*Wigglesworth 1934c* (*Rhodnius*, a bug)].

5. **Tissue culture** [Lewis 1916 (grasshopper testes); *Goldschmidt 1917* (moth testes); *Frew 1928* (imaginal discs of *Calliphora*), and Charin 1930 (malpighian tubules of cockroaches and wing-anlagen of lepidopterous pupæ)].

6. **Puncturing** (a) the chitin to produce scars to mark selected points during development, these scars being passively transmitted to the underlying new cuticle through several instars [*Lew 1934* (dragonfly eye)]; (b) the wing-anlage to produce defects either to mark a selected point, determine the regulative power, or study the spread of the determination process [Goldschmidt 1920, Giersberg 1929, *Henke 1933a*, Magnussen 1933, and Kühn & Engelhardt 1933 (Lepidoptera)].

7. **Chemical analyses** [various workers, see Needham 1929, Wigglesworth 1934a, and Hoskins & Craig 1935].

8. Modification of environmental factors [used by various workers: Shull 1929 ff., (temperature and light on aphids); Plunkett 1926, Driver 1931, Goldschmidt 1931b and Luce 1935 (temperature on *Drosophila*); Kühn 1926 ff., Süffert 1924, *Feldotto 1933* (temperature on moth wing-patterns); Geigy 1931 irradiation of *Drosophila* with ultra-violet rays), etc., etc.].

9. Genetic analyses of 'normal' mosaics, intersexes and gynandromorphs [used by various workers, notably Goldschmidt 1922, 1931a (Gypsy moth); *Sturtevant 1929* and Dobzhansky 1931 (*Drosophila*)].

III. HORMONES IN DEVELOPMENT

1. Nymphal ecdysis (moulting) hormone: In the blood-sucking bugs *Rhodnius* and *Triatoma*, Wigglesworth (1934b, c, 1935) has definitely shown the presence of an ecdysis or moulting hormone which is the same for all nymphal stages. This is proved by the fact that insects sharing the same blood moult simultaneously irrespective of age. Ecdysis normally occurs at a definite interval after feeding but if the head is removed or the nerve cord severed in the prothorax before a certain critical period the insect continues to live but does not moult. Accordingly there must be some stimulus from the distended abdomen transmitted via the ventral nerve cord to the brain which in turn initiates ecdysis. Presumably the hormone is secreted by the corpus allatum since this is the only gland associated with the brain that shows histological changes at this time and since severing the nerves between the brain and corpus allatum seems to prevent moulting. The hormone is not species specific since the effect can be induced in *Rhodnius* by blood from the related genus *Triatoma*. It is not the direct agent of ecdysis; it stimulates the epidermal cells which in turn accomplish the moulting process.

2. Larval ecdysis (moulting) hormone: This is also dependent on an active hormone which is non-specific for either stage or species, but whether or not the ecdysis hormone of nymphs and larvæ are the same chemically cannot be ascertained until at least one of them has been isolated.[2] The moulting of starved

[2] Their being the same would not particularly affect, much less invalidate, Berlese's theory of metamorphosis (see Introduction) which makes nymphs and larvæ non-homologous stadia.

individuals proves conclusively that growth is not the direct cause though it must be a factor (Pruthi 1925, Titschack 1926).

Buddenbrock (1930) injected blood from caterpillars ready to moult into caterpillars that had just moulted and obtained some premature moulting. Bodenstein (1933a) transplanted caterpillar legs onto younger and older caterpillars of the same stadium—the transplant and host moulted synchronously. The same effect was obtained by transplanting legs to different species of the same genus, thereby showing the nonspecificity of the hormone.

Also, although doubtless under hormonal control, it is unknown why certain species vary in the number of moults, especially variation between different seasonal broods of a single species (Arendsen Hein 1920, Roubaud 1927 and others). Kogure (1933) suggests that increase in the number of moults of the silkworm larva is caused by lack of food, decrease by climatic factors, especially light and temperature. However, at least in the locusts, an additional moult is controlled by inherited factors of a sex-limited or sex-linked nature (Key 1936). The only conclusion that can be made is that change in the number of moults may be the result of either specific genetic factors or any of several environmental factors. Further data are necessary before a satisfactory explanation can be formulated (compare variation in diapause phenomena, section VIII).

3. Nymphal metamorphosis: Wigglesworth (1934b, c, 1935) demonstrated a second chemical (hormone) in the blood which is responsible for metamorphosis from the nymphal condition to adult in *Rhodnius* and *Triatoma*. Precocious metamorphosis can be induced in fourth or even first instar nymphs by 'perfusion' with blood of a fifth (last) instar nymph. This hormone must be in the nature of an inhibitor which is produced in quantities near the threshold value since simple mixing of the blood of a moulting fourth instar nymph with blood of another fourth instar nymph decapitated soon after feeding, with consequent dilution of the hormone, causes both to metamorphose. This, as well as the origin of the hormone, is also shown by transplanting the corpus allatum from a fourth instar nymph into a fifth instar nymph; the latter develops into a nymph instead of an adult. It is not yet certain whether the nymphal and metamorphosis hormones are

chemically distinct or only two different quantitative expressions of a single substance. Like the ecdysis hormone it is not species specific.

4. Pupal metamorphosis: The onset of pupation is due to a hormone which is probably qualitatively different from the larval ecdysis hormone. However, in the light of the following data, it does not seem clear as to whether this 'pupation hormone' should be viewed as a positive stimulator of pupation or the release of an otherwise autonomous organism from a previous inhibitor or both. Also, it is not clear whether the factors which break diapause (*q. v.*) are similar to those which cause metamorphosis or whether other factors are involved.

Kopeć (1922a) reported a certain critical period before which removal of the brain of a caterpillar inhibited pupation whereas later removal had no effect. He therefore postulated the brain as an internal secretory center or stimulator, but later (1927) questioned the interpretation. Caspari & Plagge (1935) repeated these experiments on sphinx moths and obtained similar results. They also report that if a brain from a normal mature caterpillar is transplanted into a caterpillar de-brained before the critical period, pupation ensues (they make no mention of the corpus allatum but unless they transplanted this gland along with the brain their data will not fit into the general picture as given here). They also report that if a larva is completely constricted before the critical period only the anterior part pupates. Buddenbrock (1930) accelerated pupation by injecting blood of pupating caterpillars into younger ones. Sometimes, however, he obtained only ecdysis which might indicate that moulting and pupation hormones are qualitatively the same. Bodenstein (1933a) reported that transplanted larval legs moulted synchronously with the host even when older than they would have been at the time of metamorphosis if left on the donor, but that they were invariably cast off at pupation. From this he inferred that pupation not only differs quantitatively from ecdysis but that it is caused by different factors (hormones). Conclusive data are presented by Fraenkel (1934, 1935) who reports that if blow-fly prepupæ are securely ligatured not more than twelve hours before pupation both parts pupate, the posterior part 1–3 hours after the anterior,

but if prepupæ are ligatured more than twelve hours before pupation only the anterior part pupates or else neither does. If the ligature on an early prepupa is removed both parts pupate at the same time (proving that injury is not responsible for the non-pupation of the posterior parts). This is definitely shown to be a hormonal effect by injecting blood of prepupæ about to pupate into the posterior parts of prepupae ligatured 24 hours previously. Such posterior halves, which would never have pupated without the injection, pupated in about 50 per cent of the cases although some required a second injection 24 hours after the first.

The Lepidoptera and most of the other orders of insects possess well developed corpora allata (see Ito 1918), and, in view of Wigglesworth's data on *Rhodnius* nymphs, it is natural to look to these glands for the source of the hormones in holometabolous insects. However, the higher Diptera are said to lack any homologue of this gland; no suggestion can be made as to the source of the secretion other than that it must be produced in the anterior end of the body.

This conception of two competing hormones, one stimulating growth, the other inhibiting metamorphosis, also provides an explanation of prothetely (appearance of pupal characters in the larva) and metathetely (retention of pupal characters in the adult) if we assume that the first represents a premature release of certain of the embryonic tissues from the influence of an inhibitor, the second the failure of such release at the normal time (Wigglesworth 1934a, c). The startling report by Brecher (1932) of the development of two adults of the butterfly *Vanessa* direct from the larva without pupation may be an extreme case of this sort of hormonal unbalance, but the brief abstract published is not convincing since she was unable to ascertain whether or not the crumpled larval skins adhering to the adults contained pupal skins.

5. Imaginal or adult metamorphosis: The data for this subsection are considerably less conclusively than those for the above hormones. Frew (1928) reports that imaginal discs of blow-fly larvæ will not evaginate in carefully filtered (bacteria-free) larval blood but will evaginate and form a segmented limb in similarly

prepared pupal blood. By varying the inorganic salts he shows that this is not due to any change in the osmotic pressure of the body fluids. Bytinski-Salz (1933) transplanted ovaries and wing-anlagen of non-developing hybrid moth pupæ into normal pupæ (*i.e.*, parent stock of the hybrids). He found that these organs which will not develop in the donor do develop normally and completely under the influence of a normal host. Conversely, ovaries of normal parents transplanted into hybrids show no development before the host dies. Bytinski-Salz therefore postulates a developmental center at a particular time and place in the pupa, and further that this center acts as or controls an internal secretory center. It would seem from these data that in addition to a hormone causing pupation there is another hormone (or quantitative expression of a hormone?) necessary for the development and differentiation of the adult within the pupa.

When the growth processes of the pupa are disturbed by centrifugation or by operations performed on larvæ, histiogenesis may be retarded and the adult emerge while its internal tissues are still in a stage characteristic of the pupa. In such cases completion of the histological differentiation may take place in the adult (*Lina populi*, a beetle, Guareschi 1934b; *Drosophila melanogaster*, Richards unpubl. data).

6. Reproduction: Wigglesworth (1935, 1936) reports that the corpus allatum of the adults of *Rhodnius* and *Triatoma* produces a hormone distinct from the moulting and metamorphosis hormones of nymphs. This hormone controls the production of eggs. Adults deprived of this gland do not develop eggs, but adults deprived of it and receiving blood from another adult which possesses this gland produce eggs in normal manner. A similar effect is quite possible in holometabolous insects since, for instance, Ito (1918) shows that the corpus allatum of various Lepidoptera increases in size and presumably in functional activity in the adult.

7. "Hormones" affecting genetic characters: There are a few cases in which recessive genetic colors are suppressed by the presence of dominant-type tissue within the individual. This may be either by a contact-diffusion effect or by a more general

effect via the blood. In the moth *Ephestia* and in *Drosophila* it is proven that the "hormone" is not the product of any single organ or tissue—seemingly it is a more or less general property of dominant-type tissues.

Dobzhansky (1931) reports that genetically white testes (recessive color) become yellow with age in gynandromorphs of *Drosophila simulans* which contain wild-type tissue. Sturtevant (1932) reports that vermilion eye-color is almost always suppressed in gynandromorphs when wild-type ovarian tissue is present although other organs or tissues are also concerned. This has been conclusively proved by Ephrussi & Beadle (1934) and Beadle & Ephrussi (1935) by transplanting vermilion eye-anlagen of *Drosophila melanogaster* into the abdomen of wild-type hosts—the grafted eyes develop the wild-type coloration. They also report a similar suppression of cinnabar eye-color in wild-type hosts. They tested numerous other eye-colors and found that only vermilion and cinnabar were suppressed or changed. A. R. Whiting (1933, 1934) has shown a similar relation between recessive eye-color and some part of the abdomen in gynandromorphs of *Habrobracon* (wasp). Caspari (1933) reports that in the moth *Ephestia* testes from black-eye stocks with colored testis sheath (dominant character) implanted into larvæ of red-eye stock with colorless testis sheath (recessive allelomorph) give brown- or black-eye adults with partially colored host testes; and that colorless red-eye stock testes implanted into black-eye stock larvæ become partially colored regardless of whether the host is male or female. Caspari has thereby shown an effect of dominant-type tissue upon recessive-type tissue irrespective of which is graft and which host, that this effect is transmitted through the blood, and that the chemical ("hormone") that produces the effect cannot be the product of any single organ or tissue.

There is only one case of the modification of a genetically dominant character in gynandromorphs. Sturtevant (1932) reports a contact effect of non-bar tissue (recessive) on bar tissue (dominant) in certain parts of the eyes of *Drosophila*. He adds that the data may possibly indicate a time of determination effect (see Section V-A).

IV. THE 'DIFFERENTIATION CENTER' AND THE INFLUENCE OF THE NERVOUS SYSTEM

In the last section it was shown that stimuli from the brain to some other part of the body are necessary for the production of most (perhaps all) of the hormones now known to be concerned in larval and pupal development. In addition to this hormonal control there is the observable fact that in holometabolous insects the visible differentiation of the adult body begins in the pupal thorax and spreads thence anteriorly and posteriorly just as does differentiation of the larval structures in the embryo. That this represents a gradient-field phenomenon (see Section VI) similar to that of the embryonic differentiation center is indicated by two different sets of experiments: First, Geigy's report (1931b) that sensitization and desensitization to ultra-violet rays proceeds from the anterior part of the thorax posteriorly. Second, Bodenstein's report (1934, 1935) that fore leg anlage transplanted to hind leg positions develop the histological structure of fore legs but the form and size of hind legs. These data seem explainable only on a gradient-field concept such as a developmental center, especially since studies on regeneration (*q. v.*) show that the nervous system does not directly affect the differentiation of external form.

Hacklow (1931) made extensive experiments on various butterflies attempting to show that this differentiation center is located in the thoracic nervous system. Although there seems to be a differentiation center in the pupal thorax, its location in the nervous system is questionable. What has been shown (Crampton 1899, Kopeć 1922a, Hacklow 1931, Geigy 1931b, Hey 1932, Guareschi 1934) is: (1) that sensitization and desensitization to ultra-violet rays and centrifugal force (determination) proceed from the anterior part of the thorax posteriorly; (2) presumably also from the thorax anteriorly (as in the embryo) since there is clearly no developmental center in the head; (3) that differentiation of the abdominal segments does not occur if thoracic differentiation is inhibited or if the abdomen is separated from the thorax, but (4) abdomens grafted in natural or unnatural positions onto other pupæ develop normally although only the superficial tissues fuse, and (5) the thoracic and/or cephalic ganglia are somehow concerned either as causal factors (Hacklow) or as a link in a chain of reactions (Kopeć, Wigglesworth (1934a)).

Two contrary sets of data seem likely subject to other interpretations rather than consideration as exceptions. Crampton (1899) obtained adult parabiotic twins from two pupæ fused in the mesothoraces. Each member had only the posterior half of the mesothorax, the metathorax and the abdomen (thereby lacking any anterior thoracic differentiation center), yet normal and complete development ensued. An effect prior to the time of operation seems likely (exact ages not given). Metalnikov & Korvine-Kroukovsky (1927) claim that destruction of any ganglion of the bee-moth larva inhibits metamorphosis and that the metathoracic ganglion is most important since its destruction causes paralysis.

Unfortunately Peredèl'skii's paper (1930) could not be obtained.

The conclusion, then, is that the 'differentiation center' is not a function of the nervous system, and that the influence of the nervous system is limited to stimulating the production of the hormones already discussed, to controlling (probably *via* hormones) the development of pupal- and perhaps also wing-coloration of butterflies (Brecher 1924a, b, Giersberg 1929), and to affecting the histological differentiation of certain internal tissues, notably muscles (see Section V-C).

V. ORGAN DEVELOPMENT

A. The Eye and Central Nervous System

Lew (1934) analyzed the normal development of the nymphal and adult eye of various dragonflies by making minute scars in the hypodermis of the nymphal head capsule. By experiments on various species he shows that the functional nymphal eye contributes only a small part of the adult eye in lower forms, and that in higher forms the nymphal eye is either reduced to a small, functionless area at the posterior margin of the eye or lost entirely. Further, that the adult eye develops by receiving new tissue from instar to instar from a budding zone at the inner margin, this new tissue consisting of incompletely developed ommatidia which do not become functionally mature until the adult stadium. Histologically he differentiates three types of tissue which together make up a mosaic eye: the first forms the func-

tional nymphal eye which is displaced and functionless in the adult Libellulinæ; the second (covered by wrinkled cuticle in the nymph) forms the large facets of the adult eye; and the third (the one structurally incomplete in the nymph) forms the small facets that comprise the greater part of the adult eye. The adult eye of Odonata, then, is not just an enlargement of the nymphal eye but is composed largely or entirely of areas of the head capsule outside the boundaries of the functional nymphal eye.

The eye is a self-differentiating system. It is not dependent on the brain since Kopeć (1922b) showed that when the brain of a caterpillar is removed the complete set of ommatidia develop down to the lamina ganglionaris, the only effect of the absence of the brain being that the nerve fibers growing in from the retina are irregularly directed. The anlage is also independent of its position within the body, since when it is transplanted into the hypodermis of the abdomen it undergoes complete differentiation producing the full quota of normally and fully developed ommatidia although it makes no connection with the nervous system (Kopeć 1922b). Ephrussi & Beadle (1934) and Beadle & Ephrussi (1935) obtained similar but less complete results with *Drosophila*. The flies differ from the moths in that the eye anlage is invaginated into the body cavity instead of being part of the head capsule. The reversed relationships (pigment cells outside, lenses inside) reported by Beadle & Ephrussi for their *Drosphila* grafts is probably due to a failure of the anlage to evaginate.

No attempt will be made to review the voluminous genetic work on the eye of *Drosophila*. Study of mosaics, gynandromorphs and transplanted eyes show that the colors usually undergo autonomous development determined by the genetic constitution of the tissue. The only exceptions are vermilion and cinnabar (see Section III-7). The extensive series of colors is partly due to various combinations of the several pigment elements (see Schultz 1935). The bar-eye series of mutants show in part a dependence on temperature and modifying genes (Driver 1931, Hersh 1931, Luce 1935), but in addition that there is a central region of the eye in which complete facets are always formed, an adjacent anterior region in which pigment is present but facets not formed unless 'not-bar' tissue is near by, and a further anterior region

in which neither pigment nor facets are formed normally but in which both pigment and facets may be formed if 'not-bar' tissue is near by (see Sturtevant 1927, 1932).

Kopeć (1922b) reports that the eye anlage exerts a positive influence on the development of the brain. When the eye anlage of the gypsy moth is removed the optic ganglia of that side do not develop unless the eye is regenerated. From this it appears that the development of the optic ganglia is dependent on the ingrowth of nerve fibers from the retina. For the interdependence of the various parts of the central nervous system in later differentiation there is little data other than the observation by Kopeć that removal of the brain (supraœsophageal ganglion) of a caterpillar results in marked underdevelopment of the subœsophageal ganglion in the adult, whereas removal of the subœsophageal ganglion does not effect the development of the brain.

B. The Reproductive System and Secondary Sexual Characters

Numerous experiments on moths, beetles, flies and crickets all show that surgical castration has no effect on the genitalia, genital ducts or secondary sexual characters, even when the castration is performed in early embryonic stages (Oudemans 1899 Kellogg 1904b, Meisenheimer 1908a, b, 1909a, c, Kopeć 1908, 1910, 1911, Hegner 1908, 1911, Regen 1909, 1910, Prell 1914, 1915, Klatt 1919, Geigy 1931a, Hamaski 1932, and Howland & Robertson 1934). Similarly, moth gonads transplanted into hosts of the same or opposite sex develop normally and have no effect on the host although they may fuse with the host gonads or genital ducts (Meisenheimer 1908b, 1909c, 1910, Kopeć 1910, 1911, Umeya 1926, Caspari 1933). The independent development of the gonads is further shown by the differentiation of moth testes *in vitro* (Goldschmidt 1917). And, finally, the absence of sexual hormones affecting differentiation is corroborated by the fact that although differences have been reported between the blood of the two sexes (Steche 1912, Geyer 1913), blood transfusion in moths gives only negative results (Kopeć 1911, Umeya 1926), and regenerating antennæ of moths reproduce the sexually dimorphic characters even though the individual has been castrated and a gonad of the opposite sex implanted (Kopeć 1913b).

Gynandromorphs are in themselves natural experiments proving the generality of the independent development of both the primary and secondary sexual characters. However, one exceptional case has been reported from gynandromorphs: Dobzhansky (1931) says that testes in gynandromorphs of *Drosophila* differentiate only when in contact with vasa efferentia (the male ducts, however, develop irrespective of the gonads) and degenerate in the presence of female ducts, especially if in contact with them.

Sex reversal in insects has been obtained by only three methods: (1) genetic constitution based on interaction of male and female factors (Goldschmidt 1927, 1931a, c, Dobzhansky & Schultz 1934); (2) abnormal temperatures based presumably on a difference in the rate of action of the sex factors (Goldschmidt 1934); and (3) the action of parasites (*Stylops*) on Aculeate Hymenoptera (Salt 1927, 1931). The first may be partial or complete, the second and third are always partial. The action of parasites is somehow related to the nutrition of the larva since Salt points out that it occurs only in those forms which receive a fixed ration for larval life and since its degree is increased when several parasites are present. It is also in keeping with Goldschmidt's theory of sex determination since there is a definite sequence of the appearance and change of the characters affected. No such sex reversal occurs, for instance, in the parasitic castration of aphids by braconids (Paillot 1934). [Phasic, nutritious and other kinds of castration are elaborately reviewed by Wheeler (1910).]

An entirely different type of interaction is shown by the genitalia of mosaic males of the wasp *Habrobracon*. According to Whiting's theory of sex determination in Hymenoptera (Whiting 1933) there are two types of haploid males, and females result from the interaction of these two genetic types in a diploid individual (diploids resulting from the fusion of two gametes of the same type are usually non-visible but very rarely live and become diploid or biparental males. See Part I, section IV, 3). In mosaic (haploid) males containing both of these types of tissue, Whiting, Greg & Speicher (1934) report a feminization of the genitalia due to the interaction of the two types of haploid tissue present in the individual.

C. Muscles

Kopeć (1923) reported that the muscles of the larva of the gypsy moth do not atrophy following removal of the corresponding ganglion even when several ganglia were removed and all innervation thought broken (possibility of nerve plexi remaining). However, muscles appear in the adult in only those segments in which the ganglia of the larva were not damaged. Similarly, Kopeć (1923) and Şuster (1933) found that when a leg or antenna and its corresponding ganglion are both extirpated from moth larvæ or mantid nymphs, the appendage may regenerate externally normal but without muscles or nerves (and so functionless). Friedrich (1930) reports that in regeneration of legs in phasmids nerves appear sooner than muscles. These data prove that the differentiation of insect muscles is dependent on their being innervated even though the mature muscle, unlike vertebrate muscles, will not atrophy following severing of its nerves.

D. The Epidermis and Segmented Appendages

The differentiation of the epidermis cannot be due to the influence of the nervous system or other internal organs because of the data from regeneration cited in the last paragraph. Rather, the epidermis and appendages show the effect of the interaction of gradient-fields (see Section VI). Bodenstein (1934, 1935) shows that the problem may be divided into two subheads: (1) general form, (2) histological structure. By transplanting fore leg anlagen of third instar larvæ of the butterfly *Vanessa* to the site of extirpated middle and hind legs he found that the general form became largely transformed to that typical of middle and hind legs but that the histological structure (in this case special scale types) remained more or less typical of fore legs, the degree of similarity depending on the quantitative relationships of the two anlagen which interact to form a single leg. General form of the leg, then, becomes modified to fit its new position within the organism but the histological structure is already completely determined by this stage.

The histological differentiation of the epidermis in homœosis and heteromorphosis (Section VI), unlike that in the trans-

plantation of anlagen from third instar larvæ, is normal for the structure developed. This implies not only a considerable degree of potency beyond the prospective significance of the anlage, but that prior to the chemo-differentiation of the anlage its development is under the influence of a gradient-field whether it be in the course of normal development or of regeneration.

The reasons for the differentiation of sclerites are unknown. Anomalies in abdominal segmentation (see Section VII) show that whatever determines the general metamerism of the body also secondarily determines what parts of the abdominal epidermis will form sclerites and what parts will form membrane. The pattern of sclerites in the head and thorax is more complex, and it does not seem advisable to theorize on their determination at the present time.

The differentiation or absence of specialized cuticular sense organs in antennæ and legs regenerating without innervation is not mentioned by either Kopeć (1923) or Şuster (1933). Şuster showed by electrical and mechanical stimulation that such appendages were functionless, but that might be due merely to lack of muscles and lack of connection with the central nervous system. While one would expect the terminal sense organs to be absent in the absence of innervation, no one has reported on the point. The analysis of *Drosophila* gynandromorphs (Sturtevant, 1929) suggests that the determination and differentiation of the thoracic setæ is somehow brought about by their position. Perhaps some day the determination of sclerite and setal patterns may be interpreted as special gradient-field phenomena.

E. Wings and Wing-Patterns of Lepidoptera

The determination and differentiation of insect coloration is a complex problem. From this field the wing-patterns of moths and butterflies is selected as representative and as having received the most extensive study. Experimental studies on the coloration of Orthoptera are presented by Przibram (1919d), of the bug *Pyrrhocoris* by Henke (1924), of the beetle *Leptinotarsa* by Tower (1918) and of the wasp *Habrobracon* by Kühn (1927) and Kaestner (1931). The physics and chemistry of the colors is omitted (see Prochnow 1927, Imms 1931).

The wing and its pattern represents a self-differentiating system as is proved by the normal development (per origin) of sexually dimorphic wings transplanted onto the opposite sex (Kopeć 1922c), by the *in vitro* development of pattern in fully formed but colorless wings (Charin 1930) and by the frequently delayed development of operated wings (Goldschmidt 1920). The last two sets of data also show that the pattern is not a rhythmic phenomenon of the body and not directly related to the blood. However, Giersberg (1929) reports that if the head is amputated from larvæ of the butterfly *Vanessa* the adults are scaleless [Kopeć (1922a, b) does not mention any such effect in his de-brained gypsy moths].

From the extensive works on normal wing-development only a few relevant points can be mentioned. The primary tracheal system of the wing is mapped out by blood lacunæ before the growth of tracheæ into the anlage. This primary tracheation is different from the secondary or adult tracheation (Köhler 1932, Henke 1933a, Behrends 1935, Kuntze 1935). The adult wing is not coextensive with and frequently not the same shape as the pupal wing. The margin of the definitive wing becomes clearly marked on the pupal anlage by a marginal blood-channel, the reasons for the development of which are not known (Süffert 1929b). Although the two are normally correlated the pattern is largely independent of the gross form of the wing and of the veins and tracheæ (see Henke 1933a).

In many cases the pattern becomes partially visible before the development of any color due to the differences in scale-types (Goldschmidt 1923). These visible but non-color differences do not appear simultaneously but, like the colors themselves, appear at different times for the different pattern elements (Goldschmidt 1923, Köhler 1932, Henke 1933a). A corollary of this is the correlation of scale-type with particular coloration, both of which are normally correlated to the position within the pattern (Kühn & Henke 1932). Experimental studies to be cited below show that the wing-coloration is completely or almost completely determined long before the appearance of any pigment; developmental studies show that in the case of melanism the black pigment appears simultaneously throughout its definitive extent and

is not merely a continued production of melanin after the formation of the normal pattern (Witt 1933). A point of considerable potential significance is Köhler's report (1932) that in *Ephestia* there is a definite pattern of mitoses throughout the wing (in both the ordinary and scale-forming cells); the areas of maximum number of mitoses representing the future dark pattern elements, the minimum areas the future light pattern elements. He reports that this correlation of mitosis and maculation patterns can be carried out to details. If this is found to be of general application it will be of great importance since it will show that the result of determination is, at least in part, operative by affecting the metabolic rate of the particular cells concerned, and it will suggest that this is one of the primary effects of chemo-differentiation. It would also give a quantitatively measurable method (rate of mitoses) of studying the physiological processes involved in pattern and color development. It would be premature, however, to imply that this might be concerned in the production of different types of pigments; in *Ephestia* it is correlated only with the quantity of the melanin pigments.

The outstanding point in the determination of wing-patterns is that prior to the appearance of any pigment there are relatively brief *'sensitive periods'* during which the various pattern-components can be modified by external agents, and before and after which they are not affected by the same agents.[3] In passing from an undetermined to a determined state the cells pass through a period during which they are sensitive to, *i.e.* can be modified by, certain environmental factors. The components of the pattern do not all have the same sensitive period, and the same elements do not necessarily have the same time of determination in different species although they are constant in any one species (varying from late larva through early pupa). By applying heat, for instance, at slightly different times it is possible to modify one part of the pattern without in any way altering the other parts or the same parts on the other wing of the same side of the body. Correspondingly, by treatment through several or all the sensi-

[3] "Sensitive periods" are by no means confined to the determination of wing-patterns although they are not discussed in any other connection in this paper. See the various references given in Section II, no. 8 ("Modification of environmental factors").

tive periods it is possible to alter several or all of the recognized components (Prochnow 1914, Süffert 1924, Kühn 1926, Giersberg 1929, Feldotto 1933, and other older authors). Kühn reports that treatment at the beginning of a period reduces the size of the spots on the wing of *Argynnis* whereas later treatment increases their size.

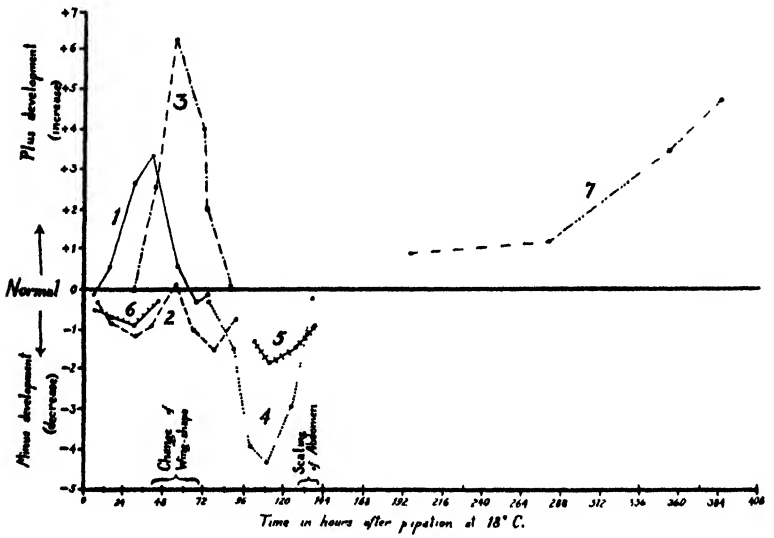

FIGURE 1.—Time of and curves of the various sensitive periods for the wing-pattern of *Ephestia kühniella* Zeller during the pupal stage. (After Feldotto, 1933.)

Legend: 1 (————) Number of dark scales in the marginal fringe; 2 (— — — —) degree of development of the cross bands of the symmetry-system; 3 (—.—.—) fusion of the cross bands of the symmetry-system; 4 (.....) loss of the marginal fringe; 5 (-|-|-|-|-) loss of maculation by loss of the scales from the wing-surfaces; 6 (-'-'-'-'-) development of transparency of the background or substrate; 7 (—·· —···) darkening of the background (true melanism). Brackets show time of sensitive periods for change of wing-shape and development of scales on the abdomen (curves for these two not determined).

[Feldotto used timed pupæ space at 6 hr. intervals from 1–120 hours.; 12 hr. intervals from 120–336 hrs., and 36 hr. intervals from 336–408 hrs. Data mostly obtained from animals placed at 44.5–45.5° C. for 45 minutes (optimum temperature for species 18° C.). Used 4611 experimental animals (of which 3420 were at ages of 1–156 hrs.) of which 1013 were modified to a greater or less degree. 1191 controls.]

It seems of especial interest that the fundamental pattern elements recognized by comparative-morphological studies (Schwanwitsch 1924, 1929, 1930, Süffert 1927, 1929a, Henke 1933b, c) are the same as those mapped-out by physiological analysis (Kühn 1926, Feldotto 1933). Further, in *Ephestia kuhniella* genetic analysis of wild populations has resulted in the isolation of stocks which have the same pattern as certain temperature aberrations (Kühn & Henke 1929). So, in all reported cases, a morphological component (*e.g.*, a particular line or particular row of spots) always acts as a unit, whether modified by temperature, simple mendelian genes or interspecific differences, but is independent of the other components. Each pattern component in *Ephestia*, as well as the scales themselves, their transparency or pigmentation, and even wing-shape, has a characteristic curve for its sensitive period (Fig. 1).

The external agents that produce these aberrations are heat, cold and certain narcotics. They cannot represent a direct effect on pigment formation since heat and cold may produce identical forms. It is a general rule that mild temperatures lighten the color, more extreme temperatures darken it. The various postulates are discussed by Giersberg (1929) who also performed experiments showing that the effect of temperature on pupæ of *Dilina tilia* is only through the head. By passing water of the desired temperature through glass tubes laid alongside the pupa he found that changing the local temperature of the body or wing during the sensitive period was without effect but that changing the temperature of the head resulted in typical aberrations. Although he had only twenty specimens he says that the results were absolutely consistent and that the effect must be *via* the nervous system, the quantity of black pigment depending on some particular stimulus from the head. How this acts is not clear. He adds that the situation must be more complicated in *Argynnis* where the pattern elements vary independently. Schulze (1918) distinguished darkening by increase in number of black scales from darkening by a general blackening independent of scale number and this is experimentally substantiated by Feldotto's data. Study of Feldotto's graph (Fig. 1) shows that enlargement of the lines (bands), fusion of lines and spots, etc., are de-

termined during sensitive periods occurring early in pupal life (curves numbers 1, 2, & 3) but that general blackening of the ground occurs much later (curve number 7) and after the pattern is fully determined. It would seem that the cephalic control obtained by Giersberg resulted in a general blackening effect without relation to (although obscuring more or less completely) the pattern, and that this cephalic control affects only the quantity of melanin produced and does not directly affect the pattern itself.[4]

The determination of the wing-pattern seems to be due to a '*determination stream*' "flowing out" over the wing-anlage and determining the pattern parts. First postulated by Goldschmidt (1922, 1923, 1934) from analysis of intersexes, the idea has been continued by Minami (1925) and Giersberg (1929) in studies on such abnormal specimens. Goldschmidt also postulated the idea of a correlation of this determination stream with different developmental velocities of the several parts of the pattern (based on the different times of their development), but Giersberg shows by localized cooling of the wing anlage of *Vanessa* during and after the sensitive periods that the pattern develops first in the warm areas, later in the cool areas, yet a normal wing always results. From this it follows that the developmental velocities have no influence on, or at least can be changed without modifying, either the color or pattern.

It is interesting to note that the structural colors, as well as the pigmentary colors, follow these lines of determination streaming. This seems likely only a special case of the determination of scale-type which is normally correlated with the determination of the color-pattern. It might be well to emphasize the fact that it has not been possible to separate the determination of scale-type, structural colors and pigments. Either they are determined coincidently or else the scale-type *ipso facto* determines the quality of both structural and pigmentary colors.

[4] The experimental induction of melanism in geometrid moths by chemicals (lead and manganese salts) and the melanics thereby obtained are not included in this discussion because Harrison & Garrett's experiments have been repeated with negative results by Hughes and by Thomsen & Lemche. For a summary of the evidence see Fischer (1933).

The comparative-morphological studies already mentioned have led to the idea of a *central symmetry-system* occupying approximately the median two-thirds of the wing and distinct from the basal and terminal parts of the pattern. Kühn & Engelhardt (1933) and Henke (1933a) show by injury experiments that the determination of this symmetry-system in moths is independent not only of the ocelli but also of the basal and terminal areas. Kühn & Engelhardt report that during the second and third days of pupal life of *Ephestia kühniella* this process spreads as a determination stream from the lower surface of the wing over the anterior and posterior margins and then proximally and distally independently of the wing veins (Fig. 2). They consider the symmetry-system as representing a self-differentiating system in contrast to the basal and terminal areas which are limited in extent by the development of the central system. Henke adds that the pattern of the terminal area represents a 'filler' of the space between the symmetry-field and the wing margin and that its pattern is illustrative of processes occurring on the periphery of a field.

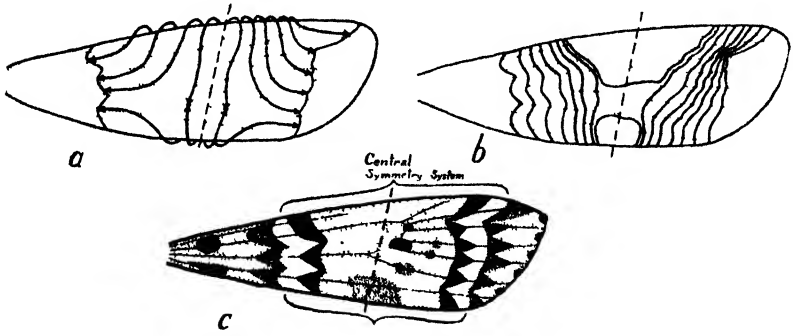

FIGURE 2. *a*. Scheme of the distribution of the determination process of the symmetry-system of *Ephestia kuhniella* Zeller as determined by local defects on the wing epithelium of 1–2 day pupæ. *b*. Scheme showing the outer boundaries of the various degrees of development of the symmetry-field following operations (local defects) on the wing anlage of 1–3 day pupæ. *c*. Diagrammatic representation of the normal wing-pattern of *Ephestia kühniella* Zeller (the limits of the central symmetry-system are indicated by brackets; the axis of the symmetry-system is shown by a broken line.) (After Kühn & Engelhardt, 1933.)

Two different types of determination processes or streams have been discussed above: (1) a determination stream "flowing out" from the wing base, and (2) a determination stream spreading from the median portion of the ventral surface over the median portion of the dorsal surface. Perhaps these are fundamentally different processes since gypsy moth intersexes show a normal symmetry-system in addition to a more or less longitudinal blotching of the sexual dimorphic coloration.

The mode of action of these determination processes (and other processes of chemo-differentiation) are unknown. It seems certainly not a matter of developmental velocities (Giersberg 1929, see above). The distribution of the process is better known. Giersberg (1929) reports that local defects on *Vanessa* wing-anlagen can produce a change in the pattern, and that this change is best explained by the postulation of the distribution of two immiscible substances during the sensitive periods, impregnation with which results in the determination of the pattern and color, interference with which hinders the distribution of one and allows greater distribution of the other. In the case of the central symmetry-system (Kühn & Engelhardt 1933, Henke 1933) it seems that the determination of this central region of the wing limits the relatively passive development of the pattern and color of the basal and terminal areas, and therefore is in close agreement with Giersberg's postulate. Gebhardt's (1912) and Huttrer's (1932) data (see below) show that the distribution of the determination process is quite similar to dispersion in colloidal solutions (Liesegang's rings). They were able to prepare gelatine and paper models that are remarkably similar to certain rather complex butterfly patterns by such dispersion phenomena from one to five centers, sometimes aided by folding the substrate. The dispersion of the determination process over the wing by some such controlled diffusion or dispersion spreading is undeniable; of what the determination process consists physico-chemically is unknown.

A comparison showing the relation between 'sensitive periods' and 'determination streams' can be given only for *Ephestia kühniella*. In this species Kühn & Engelhardt found that no determination had begun on the first day after pupation, that the

determination process proceeded during the second and third days, and was completed on the fourth day. Comparing this with Feldotto's curves (Fig. 1) we find as one might expect that the sensitive periods for the development and fusion of the cross-band (*i.e.*, development of the symmetry-system) fall largely within this time.[5] The determination process "flows like a stream" across the symmetry-system determining the parts thereof. The sensitive period is a brief stage between undetermined and completely determined tissue. The one is a process, the other a stage in that process. Naturally the two are closely related, and their interdependence is shown by the fact that an entire pattern-component varies as a unit or else not at all.

The *ocelli or eye-spots* on the wing are determined prior to the symmetry-system and are not influenced by its determination (Henke 1933a, Kühn & Engelhardt 1933, Magnussen 1933). Although the discoidal ocellus normally has a definite relation to the discoidal vein (Henke & Preiss 1930, Bryk 1931), Henke (1933a) found that the ocellar anlage of *Philosamia cynthia* bears no relation to the veins and is not influenced by operations on the tracheæ. He reports that the determination of an ocellus takes place in two steps: (1) the production of the ocellar-anlage on both wing surfaces (not in the same area where the ocellus later develops), and (2) the expansion and organization of the various zones in definite order of precedence from the inner parts outwardly. The latter is independent on the two wing-surfaces, the former is not. Gebhardt (1912) and Huttrer (1932) point out similarities between these determination processes, especially ocelli, and the purely physical formation of Liesegang's rings in colloidal solutions. Some of the figures they obtained are quite suggestive. Perhaps some of the complex multiple line and concentric ring figures found in certain Lepidoptera are the result of a determination process that disperses in the manner of Liesegang's phenomena.

As will be discussed later (Section VIII) Süffert (1924) showed that the seasonal forms of *Araschnia* are due primarily

[5] Only two of the seven curves given by Feldotto (Fig. 1) are concerned here. These are curves numbers 2 and 3. The other five curves are not or at least not directly concerned with the determination of the symmetry-system.

to the type of development undergone by the pupa. Thus diapause pupæ give the "spring form" and non-diapause pupæ normally give the "summer form" regardless of whether kept cold or warm. This is complicated by the fact that non-diapause pupæ can be made to give the "spring form" coloration by the application of cold during the brief sensitive period. But the fact that diapause pupæ can never be induced to produce the "summer form" unless the diapause is broken (in which case an intermediate results, the degree of intermediacy being correlated with the length of the diapause period before its interruption) implies that the type of development is the primary cause of seasonal forms at least in this species (see also Heller 1928). The experiments of Weismann (1875, 1876), Edwards (1875), Merrifield (1911) and other older authors on various species corroborate this. It seems quite probable that this explanation is of general application, and that the differences between "dry" and "wet" season forms of butterflies may have the same explanation.

These data are also quite significant to taxonomy. They show that the so-called "aberrations" are not really aberrant, and that these "aberrations" have no direct bearing on phylogeny or evolution. The production of these does show that the insect is capable of producing unusual results, but the fact that any given "aberration" can be produced practically at will and the specific results predicted with considerable accuracy merely by altering a particular component of the environment shows that there is no inherent difference between so-called normal and aberrant colorations of lepidopterous wings (naturally an accurate knowledge of the sensitive periods and careful timing of the breeding is prerequisite to predicting results). "Aberrations" are merely normal individuals which have developed under not normal conditions during some or all of the sensitive periods.[6]

[6] It is true that similar effects may result from genes and interspecific differences, but it does not follow from that that "aberrations" have any direct relation to phylogeny. Indistinguishable results do not necessarily imply that the cause is the same, and the experimental data show conclusively that "aberrations" are only normal individuals and so have no phylogenetic status. Erroneous reasoning on the part of certain individuals has lead them to think that "aberrations" were of phylogenetic significance, and to devise "systems" to show their evolutionary significance. All that "aberrations" show

F. Imaginal Discs of Higher Diptera

By detailed analysis of ninety-six gynandromorphs of *Drosophila simulans*, Sturtevant (1929) has shown not only that the cleavage nuclei are clearly indeterminate (since there is never any indication of a general pattern among mosaics) but also that the presumptive imaginal discs are mapped out at an early stage. He selected thirty-six parts showing mosaicism and, tabulating his data, says, "There appear to be modes at 18, 9 and 5 parts male. These correspond to 50 per cent, 25 per cent and 13 per cent of the possible 36 parts. Evidently they correspond also to cases in which one of the first two, first four or first eight cleavage nuclei were male, *i.e.*, to elimination of an X chromosome at the first, second or third cleavage division respectively." This indicates that the cortical protoplasm of the egg of *Drosophila* is not only determined for the parts of the embryo but also (perhaps secondarily) mapped out for the adult via the imaginal discs. These data are valid only for prospective significances.

Geigy (1931b) reports that the imaginal anlagen are not predetermined in the cortical layer of the egg since he was unable to produce imaginal defects by ultra-violet irradiation before the time of contraction of the germ band (*i.e.*, after the embryo is formed). Therefore he postulates two determination periods for the higher Diptera: the first for the embryo and larva, the second for the adult via the imaginal discs. The first is completed by the time of fertilization, the second is not finally completed until the pupal stadium since similar defects can be produced by irradiating larvæ and young pupæ. But Smith (1935) reports similar non-hereditary defects from x-irradiated female gametes and thereby leads to questioning the validity of Geigy's two determination periods. Perhaps the discrepancy can be traced to the different types of irradiation used but it seems best to leave it an open question.

Sturtevant (1929) further shows that some imaginal discs (*e.g.*, wing discs) regularly contain more blastoderm nuclei than other

is that the wing is capable of producing patterns different from that usually found (they also afford a method for studying pattern determination). Comparative studies of the pattern within a group may, and frequently do, give indications of the evolution within that group, but "aberrations" do not.

smaller discs (*i.e.*, the size of the disc is a fair indicator of the number of blastoderm nuclei it contains). That in keeping with the distances apart of the points of origin of the imaginal discs, adjacent segments of one side of both thorax and abdomen are much more alike than are opposite sides of any one segment, *i.e.* the visible points of origin of the imaginal discs give an accurate picture of the earlier positions of their presumptive anlagen. That there is no determinate cell-lineage within the discs although related cells clearly tend to remain together; the differentiation of the cells (*e.g.*, setæ) occurs later independent of their origin but somehow brought about by their position. And that the prospective significance and prospective potency of the discs are almost identical since dorsal thoracic and abdominal discs only rarely produce parts belonging to the other side of the body (*vide* 'half-thorax' specimens), but that this is less rigid for the cephalic discs which seem not to give rise to sharply demarcated regions of the head.

G. 'Self-Differentiation' of Anlagen

The above sections on organ development show that, except for the necessity of growth and metamorphosis hormones, the various parts represent largely self-differentiating systems, *i.e.*, the various organs and parts are usually capable of development independently of the parts normally associated with them. This is admirably demonstrated by the complete development and differentiation of testes and the almost complete differentiation of leg anlagen *in vitro* (Goldschmidt 1917, Frew 1928), by the development of gonads transplanted into the opposite sex (Meisenheimer, Kopeć, etc.), by the development of mosaics and gynandromorphs, by the development of eye anlagen implanted into the abdomen (Kopeć 1922b, Beadle and Ephrussi 1935), by the inside-out development of a twin embryo within the body of its partner (Seidel 1929), and by the striking case of a genetic stock of the Gypsy Moth which is wingless yet in which the pupal cases possess the characteristic wing-pockets (Goldschmidt 1927).

Cases of an organ or part being dependent on another part or on the body as a whole (except for the hormones already mentioned) are less common. The outstanding cases are the absence

of muscles in the absence of the corresponding ganglia (Kopeć 1923, Šustèr 1933); the failure of testes to differentiate in gynandromorphs of *Drosophila simulans* unless they make contact with the male ducts and their degeneration when in contact with female ducts (Dobzhansky 1931), and the modification of the external form and size of butterfly leg anlagen to correspond to their position within the host (Bodenstein 1935). The first shows the necessity of innervation for muscle development; the second an unique case of the dependence of developing testes on their ducts; and the third presumably an interaction of gradient-fields in leg development (see Section VI). Another type of interaction is in the feminization of genitalia in mosaic males of the wasp *Habrobracon* (Whiting, Greb & Speicher 1934). Stylopidization ("parasitic castration") of Aculeate Hymenoptera, frequently involving a partial sex-reversal, is another special case that has been discussed above.

VI. REGENERATION AND GRADIENT-FIELDS

Of all the topics covered in this paper regeneration was the first to receive experimental study. As early as 1829 Heineken reported that the antennæ of young cockroaches were capable of being regenerated following amputation; in 1837 Müller reported the same for phasmid legs, and in 1844 Newport reported the regeneration of legs in Lepidoptera. Hundreds of papers have followed—of these only a selected set can be cited to illustrate the important points and the extent of the work. The results show considerable regenerative power for the external parts of various species of Thysanura, Odonata, Orthoptera (saltatorial and gressorial), Ephemerida, Hemiptera, Thysanoptera, Dermaptera, Embiidina, Coleoptera, Lepidoptera and Hymenoptera, and also for certain internal organs of Lepidoptera. Unfortunately no direct data are available for the Diptera except Kammerer's questionable paper (1907) on the regeneration of the wings of adults, but 'hereditary homœsis' or the development of an anlage into a structure typical of a different region of the body (*e.g.*, an antenna replaced by a tarsus) might possibly be compared with heteromorphic regeneration to be discussed below (Bridges & Morgan 1923, Astauroff 1929, Balkaschina 1929, Bridges & Dobzhansky 1933).

As Huxley & DeBeer (1934) and others have pointed out, regeneration is distinct from embryonic regulation discussed in Part I of this series. During early embryonic stages the loss of a small portion of tissue does not necessarily imply the loss of any particular anlage since regulation is possible within a gradient-field. Later, at different times in different insect groups, the various anlagen become chemo-differentiated ("mosaic stage of development"), and regulation is no longer possible (Part I, Section VI). Later still the power of regeneration appears. Regeneration is intimately associated with growth, and the onset of the capacity for regeneration is connected with the onset of the capacity for growth. "Regulation and regeneration must therefore be carefully distinguished, since they involve developmental processes which are very distinct, and are operative at different periods of the life cycle" (Huxley & DeBeer, 1934, p. 419).

A. Structures Reported Capable of Regeneration— A Literature Index

Nymphs and larvæ: Antennæ (Kopeć 1912a), 1913, Brecher 1924c, Gabler 1932, Lengerken 1933, Friza & Przibram 1933, Şuster 1933a, Sweetman 1934); *compound eyes* of beetles, moths and phasmids (Werber 1905, Kopeć 1913a, 1922b, Janda 1926); certain caterpillar and beetle *mouthparts* (Megušar 1907b, Kopeć 1912a, 1913a); *legs* (Kellogg 1904a, Megušar 1907b, Janda 1910, Kopeć 1923, John 1923, Duskova 1926, Benazzi 1929, Heldmann 1929, Şuster 1933b, Sweetman 1934); *spiracles* (Staudinger 1930); *imaginal discs of wings* of beetles, moths, dragonflies and mantids (Megušar 1907b, Meisenheimer 1908c, 1909b, Janda 1910, von Ubisch 1911, Kopeć 1913a, 1922c, Křiženecký 1914, Magnussen 1933, Oka & Furukawa 1933); *cerci* of Thysanura and Dermaptera (Sweetman 1934, Furukawa 1933); *bristles, body warts* and *caudal horn* of lepidopterous larvae (Megušar 1907a, Kopeć 1912a, 1913a, Bodenstein 1930, 1933a, e); *larval gills* of dragonflies (Perfiljew 1923); and the entire *terminal abdominal segment* of young nymphs and larvae (Megušar 1907b, Křiženecký 1913) or even the two or three terminal segments including the internal organs (Megušar 1907b, Oppenheim 1908).

Pupæ: Crampton (1899) reported no regeneration of lepidopterous antennæ and wings but merely formation of integument

over the wound. However, Hirschler (1903) reported partial regeneration of the amputated last three abdominal segments of young moth pupæ, including specific organ regeneration (hind gut and genital ducts). Kříženecký (1912), Magnussen (1933) and Henke (1933a) report that defects on pupal wing anlage are not regulated although those on larval anlage are (loss of regulative as well as regenerative power in pupa).

Adults: Werber (1907) and Kammerer (1907) report the partial or almost complete regeneration of wings extirpated from freshly emerged beetle and fly adults. In the beetle *Tenebrio* Werber reports that the elytron regenerates only when the wing is also removed. In the flies *Musca* and *Calliphora* Kammerer reports a compensatory reduction of the unoperated wing following unilateral extirpation and during regeneration. These results were based on very few specimens and seem never to have been repeated. The photographs accompanying the papers look authentic, but in addition to a general skepticism the present author suggests that the "compensatory reduction" really represents the partial collapse of the unhardened wing following reduction of the blood pressure caused by removal of one wing, due at least in part to loss of blood and perhaps also in part to the shock of the operation.

Przibram (1932, 1935) observed the development of a wing-like structure on the wounded coxa of an adult mantid. This is reminiscent of Richardson's (1889) finding in nature a moth one of whose legs was replaced by a wing. Przibram also reports that an antenna of *Sphodromantis* amputated on the day of metamorphosis can regenerate as a small segmented appendage and that earlier antennal regenerates can continue to develop during adult life. Thysanuran adults continue to moult and show regenerative powers (Sweetman 1934).

Internal organs: The gonads are never regenerated (Meisenheimer, Kopeć, Regen, *et al.*); neither is any part of the central nervous system (Kopeć 1918, 1922b, 1923, Şuster 1933). However, the egg ducts and proximal part of the vas deferens of moths are frequently regenerated (Kopeć 1923, Caspari 1933), and also the hind gut and genital ducts in the cases of regeneration of the terminal abdominal segments (Hirschler 1903). Fat and tra-

cheæ of moths metamorphose normally despite operations and seemingly exhibit a certain amount of regenerative power (Kopeć 1923) but the wing tracheæ become finally determined and incapable of regulation about the time of pupation (Henke 1933a). Muscles regenerate and appear in the adult only when the ganglion of the segment is left intact (a leg or antenna may regenerate externally normally but without muscles or nerves when both ganglion and appendage are extirpated. Kopeć 1923, Şuster 1933). Friedrich (1930) reports that the order of regeneration of the internal tissues of the leg of the mantid *Dixippus* is nerves and tracheæ, then muscles and sense organs. He believes the tissues are all derived from the epidermal part of the organ-stump. In a certain sense the transformation of the muscles and digestive epithelium during pupal life can be considered regeneration, as may also the renewal of the worn out digestive epithelium throughout life.

B. Summary of Results from Regeneration

Stages during which regeneration occurs: (1) Regeneration other than mere wound healing is usually possible only at the time of ecdysis, and the reproduced part becomes more nearly perfect with subsequent moultings. (2) Accordingly, regeneration is not to be expected in the adult except in the Thysanura which continue to moult after attaining maturity. The cases of slight or continued regenerative-growth of antennæ and the development of a wing-like structure on a wounded coxa in *Sphodromantis* are exceptions. (3) However, regenerative-power is to a considerable degree a function of age (not merely a matter of the number of days or moults available), and the degree of regeneration is inversely proportional to the age of the insect (Megušar 1907b, Magnussen 1933).

The frequency and degree of regeneration: (4) More complex and highly differentiated organs, *e.g.* compound eyes, are regenerated less often than less complex organs. (5) The regenerated part may be normal structurally yet reduced in size; more often it is of normal size but structurally imperfect or incomplete. (6) Bodenstein (1935) says that the degree of development of the adult leg of the butterfly *Vanessa* is independent of the time of

the operation but dependent on the amount of material removed and the spatial relations of the developing leg. (7) Sexual dimorphism of moth antennæ is developed to the same degree in normals and regenerates even when the animal has been castrated and a gonad of the opposite sex implanted (Kopeć 1913). (8) However, as one would expect, heterogonic sexual characters are not reproduced in regeneration in phasmids (Przibram 1931).[7]

Suppression of regeneration: (9) Body-wart or leg regeneration may at times be suppressed by transplantation of some other hypodermal part to the site of the amputation provided the transplant covers the entire wound-surface. But if the transplant does not cover the entire wound-surface there is a regeneration from the free surface in addition to the development of the transplant (Bodenstein 1933a, c, d, e). [See also number 10.]

Determination and differentiation in regeneration: (10) In at least most cases regeneration is possible only when a stump of the organ remains, *i.e.*, a proximal part is capable of regenerating any distal portion but the animal is incapable of regenerating the entire structure (Przibram 1919c, Schaxel & Adensamer 1923). (11) Regeneration, as far as known, is controlled by the organ stump, not by the position within the body, since when a thoracic leg of a caterpillar is transplanted onto the abdomen or an abdominal leg transplanted onto the thorax and the distal part then amputated, the quality and orientation of the regenerate is determined by the transplanted stump (Bodenstein 1933e).[8] (12) The differentiation of a regenerating antenna has been reported as proceeding in a proximo-distal direction (Kopeć 1913a) but, although sometimes thus, this is not necessarily true for all structures (*e.g.*, caterpillar legs, Bodenstein 1933e). (13) Regenera-

[7] Heterogony in insects, according to Huxley (1932), is produced by the utilization of food reserves above the amount needed for normal growth. For this reason one would not expect the reduplication of heterogonic characters in regeneration in insects when the reserve has been unexpectedly called upon to replace a normal organ instead of merely elaborating an organ that is already present (just as heterogonic characters are not or are only slightly developed in females where the food reserve is needed for the development of eggs). The time factor may also be concerned.

[8] No experiments comparable to those showing the non-specificity of regeneration-buds in Amphibia have been performed with insects.

tion of epidermal structures is independent of the nervous system; regeneration of muscles is dependent upon their being innervated.

Heteromorphic regeneration: (14) At times regeneration may be heteromorphic, *e.g.*, an amputated antenna regenerates as a leg or an eye as an antenna-like structure (Janda 1913, Friza & Przibram 1933). In all cases reported for insects the heteromorphic structure is one typical of a more posterior region of the body. Przibram (1934) reports that the percentage of phasmid antennæ regenerating as legs (in contrast to ones regenerating as antennæ is increased by (a) amputation from older individuals, (b) amputation of a greater portion of the organ, and (c) lowering the temperature during regeneration. These facts suggest a gradient-field relationship (see below). (15) There is no absolute relationship between the level of section and the type of regeneration but there is a tendency for an amputated antenna to regenerate as an antenna if cut through the flagellum, as a leg if cut through the basal two segments (Brecher 1924c, Friza & Przibram 1933). Borchardt's claim (1927) that the Johnston's organ in *Dixippus* exerts a truly formative influence on the regenerating antenna is refuted by Friza & Przibram (1933) who found no constant relationship, and also by a comparative study in phasmids where only certain genera exhibit heteromorphic regeneration regardless of whether the Johnston's organ is removed or left in the antennal-stump (Przibram 1931). (16) Balkaschina (1929) reports that acceleration of the rate of development of antennal anlagen of *Drosphila* to the rate of development of normal leg anlagen, by gene action, results in an 'antennal foot.' Friza & Przibram (1933) cite this as supporting Przibram's hypothesis (1919b) that relative developmental velocities affect the type of regeneration. Przibram (1919a), Benazzi (1929, 1931), Bodenstein (1933e) and others all maintain that 'normal' regeneration represents local acceleration of growth, but the different growth-rates mentioned here are not necessarily comparable. In conclusion it seems best to say that although there is sometimes a correlation between developmental velocity and type of regeneration, it remains to be proven whether or not there is any causal relationship between the two.

C. *Gradient-Fields*

A gradient-field is a region with a central or terminal high or dominant point with a graded degree of the potency concerned from this high point outward in all directions or along a main axis. It may include the entire organism, for instance the primary axis of the egg, or only a portion of the organism, for instance a limb-field in Amphibia. Gradient-fields have been extensively analyzed in *Planaria*, Amphibia and certain other forms, and a detailed discussion of these data is given by Huxley & De-Beer (1934). The inclusion of the topic here is largely based on comparision with these other groups.

Hartzell (1934) reports that the anterior end of the larva of the Tomato Worm moth (*Protoparce sexta*) is more susceptible to pyrethrum extracts than the posterior end. This implies a longitudinal gradient of susceptibility with a high point at or near the anterior end of the body though it may be due to the nervous system rather than the body as a whole. The action of the embryonic differentiation center is another example of a longitudinal gradient whose high point is in the thoracic region. More comparable data are supplied by Bodenstein (1935) who transplanted the fore legs of caterpillars onto middle and hind leg positions. He found that the adult legs developed from such transplants had the histological structure (special scale-types) of fore legs but the form and size of middle and hind legs. This is analogous to the modification of Anuran presumptive belly epidermis grafted into the future mouth region of an Urodele egg where it gives rise to Anuran type mouth tissue, which Huxley & DeBeer (1934, p. 321) call the interaction of a gradient-field of primary effect with one of secondary effect. Bodenstein also reports that the ectodermal part of the larval leg lying outside the area of the presumptive adult leg anlage is capable of inducing leg-regeneration. This could be compared with Amphibia where the limb-field is of greater extent than the presumptive limb. Goldschmidt (1921) makes use of another of the principles of gradient-fields to explain duplication in the male genitalia of intersexual Gypsy Moths. He noted that the chitinous ring of the ninth abdominal segment was much broader in intersexes than normals. Since both valves and penis develop from a single

anlage, the valves beginning to develop next to this ring, a space is left between the developing valve and penis. He says that two high points develop when this spatial isolation is sufficiently large, and, accordingly, two valves develop, one next to the segmental ring, one next to the penis. All of these data can be explained on a gradient-field hypothesis.

The comparison of gradient-fields in insects with those in other animals is most fruitful when regeneration is considered. There are two important points: (1) Regeneration is usually possible only when the stump of an organ remains. This is strictly analogous to the absence of regeneration in Urodeles after removal of the entire limb-field in contrast to complete regeneration when only part of the field is removed. (2) Heteromorphic regeneration, as pointed out by Huxley & DeBeer, is best explained by the assumption of a flattening of a gradient-field since that is the only concept which will systemize the data summarized above under numbers 14-16.

VII. TERATOLOGICAL PHENOMENA

No attempt will be made to cover the subject of teratological phenomena in detail. Pro- and metathetely have already been mentioned in Section III-4, and homœosis and heteromorphosis in Section VI. A few additional notes will be given and the reader is referred to Przibram (1920) for a detailed classification.

Duplications and triplications have been mentioned in Part I. They may be experimentally produced by dividing an anlage mechanically (see Part I), by duplication of anlage by transplantation performed in such manner that both anlagen develop (Bodenstein 1933c, e), or, presumably, by the development of two high points in a gradient-field (See Section VI-C). Bateson (1894) pointed out that in triplications, whatever the mode of origin, the several structures always lie in the same plane and that two of the components are always mirror-images of one another (duplications may or may not be mirror-images). Bateson's rules have been abundantly confirmed by Przibram (1921) and others, but the cause of the formation of mirror-images is still obscure and has given rise to considerable controversy. For a theoretical discussion see Przibram 1924.

Anomalies in body segmentation: In Part I it was pointed out that duplication in the longitudinal axis of the body is unknown. However, certain anomalies of segmentation do occur either naturally or as experimental by-products. Usually they appear sporadically but in some cases they (or the tendency to form them) are definitely heritable. Cases of so-called "spiral segmentation" (not to be confused with "spiral cleavage" of molluscs, annelids, etc.) have been reported by Cockayne (1929, 1934) and Learned (1932) for various moth larvæ, by Arendsen Hein (1920) for the beetle *Tenebrio*, by Cappe de Baillon (1927) for *Dixippus* and by Morgan (1915) for *Drosphila*. They are presumably the result of fusion of one segment-half with the opposite half of the succeeding segment during formation of the definitive embryo or to a similar incorrect fusion of imaginal discs in the pupa (*Drosophila*). The first might be due either to some obstacle to growth in the proper direction or to movements of the embryo during closure of the dorsal body wall (see Part I, Section VIII). The comparative rarity of ventral spirals might be due to either greater proximity or earlier fusion or both. Their principal significance in this paper is that they seem to show that whatever is responsible for the metamerism of the organism also secondarily determines what parts of the epidermis will form sclerites and what parts intersegmental membrane.

Abdominal sclerite defects (usually not "spirals") are common in *Drosophila*. In some cases they are heritable (Morgan 1915). They are especially common from irradiated eggs which indicates that the presumptive imaginal discs are highly determinate and possess little of any regulative power after injury (Geigy 1931b, Smith 1935). Stark (1918) and Richards (unpubl. data) have noted that following the mechanical injury of transplantation in *Drosophila* larvæ sclerite defects almost invariably occur in the adult. Usually this is merely the loss of part of one or more sclerites, but in one case following a dorso-lateral incision I obtained 'typical' spiral segmentation of the adult abdomen (doubtless the incision or the scar interferred with growth of the imaginal discs so that the disc destined to form one side of a segment fused with the one which should have formed the opposite half of the succeeding segment instead of the one forming the

opposite half of the same segment). No torsion of the abdomen results from these anomalies, the lost sclerite-parts are replaced by or at least their area filled with membrane. Abdominal sclerite defects have also been produced by centrifuging beetle pupæ (Guareschi 1934).

VIII. DIAPAUSE OR DORMANCY[9]

Hibernation is not necessarily the same as diapause. Bodine (1923, 1932b) shows that hibernation is not inherent but is conditioned solely by temperature even in species which do not normally hibernate. Hibernating animals have a lower water content but the rates of oxygen consumption and growth respond to changed temperature in similar manner to non-hibernating individuals.

Diapause, in distinction to hibernation, is an inherent, obligatory characteristic which may be independent of temperature for for its occurrence though its duration is affected by temperature and other factors. It is manifested as a retardation or cessation of growth, mitosis, metabolism and movements (Slifer 1931, 1932). It occurs at different stages in different species but almost always at a particular developmental stage in any one species.

For the egg of the grasshopper *Melanoplus*, Bodine (1925, 1929, 1932a, b, c, 1934a) and Burkholder (1934) have shown that the diapause factors are quickly destroyed or inhibited at low temperatures and much more slowly at high temperatures; that diapause represents an "all or none" type of reaction with a definite threshold value which is reached at a definite time after laying and at a particular development stage; and that above the development zero (18° C.) diapause is independent of temperature for its occurrence but is relatively dependent on temperature for its duration. Some species have an optimum temperature (Parker 1930).

Bodine (1934b) and Bodine & Boell (1934a, b) report that the oxygen consumption of developing eggs is markedly depressed by KCN to a small constant faction of the unpoisoned respiration of

[9] I acknowledge with thanks the criticism of Dr. David R. Goddard during the preparation of this section on diapause.

normal eggs whereas diapause eggs are almost completely resistant to the same concentrations. This is strikingly analagous to the action of KCN on fertilized and unfertilized sea-urchin eggs. They also report that the oxygen consumption of developing eggs is depressed by CO to a similar constant low level; that the oxygen consumption of diapause eggs or of developing eggs poisoned by KCN is stimulated by CO, and that this is due to the concentration of the CO rather than the length of exposure. From these two sets of data they conclude that respiration in diapause is quantitatively and qualitatively identical with the KCN and CO insensitive fractions of the respiration of developing eggs at the same morphological stage, and that therefore in diapause the respiration is depressed not merely as a passive result of decreased protoplasmic activity but by the complete suppression of the KCN and CO sensitive part of the respiratory mechanism by some unknown agent acting as part of the general diapause-producing factor.[10]

Comparing diapause and growth factors Bodine (1932c) states that the diapause factors are completely destroyed or inhibited at low temperatures whereas growth factors are only temporarily inhibited at low temperatures and quickly return to normal when placed at high temperatures. He views the diapause factors as inhibitors which beginning below the threshold value in quantity or potency increase to a point where they inhibit the growth factors completely. Later they become reduced to below the threshold value and then the growth factors resume activity. Wigglesworth (1934a) prefers not to invoke a second (inhibitor) factor. He suggests that diapause is due simply to the temporary failure of the growth promoting hormone. The available evidence does not permit making a choice between these two hypotheses. Roubaud's theory of autointoxication by waste products, while in certain respects similar to Bodine's theory, does not

[10] This, of course, does not mean that the respiratory changes are in any way the direct cause of diapause. In fact, Bodine (1934c) has shown by varying the osmotic pressure that the block mechanism of *Melanoplus* eggs is not primarily concerned with the general oxidation metabolism of the cell, and that the oxidation limits of the dormant cells may be modified without interfering with the diapause mechanism.

seem adequate to explain the great diversity of diapause phenomena throughout insects (Roubaud 1922, etc.)

Investigation of temperature coefficients, respiratory quotients, iron, peroxidase and tyrosinase content of *Melanoplus* eggs has shown no significant relationship to diapause (Bodine & Boell 1935a, b, Bodine & Thompson 1935, Bodine & Walkin 1934, and Boell 1935).

The above deals exclusively with the eggs of the grasshopper *Melanoplus* but the major premises are valid for diapause in other insects and at later stages. In eggs of the moth *Lymantria monacha,* Knoche (1932) reports that the differences in the level of respiration of diapause and non-diapause eggs vary. Therefore the degree of diapause varies in different eggs of the same species, and it is possible to intensify this difference in respiratory level by raising the humidity and to decrease it by lowering the humidity. He also reports that the time of onset of diapause is correlated with the respiratory rate (soonest when this rate is relatively high during diapause, later when it is low). In this connection it is interesting to note Readio's data (1931) on nymphs of the bug *Reduvius* in which diapause may occur at several different stages. Using growth curves he noted that diapause is progressively more intense in the later stages of nymphal development, and that the appearance of a dormant period in the third or fourth nymphal stadium usually obviated a diapause period in the succeeding stadium, and, conversely, its absence in either of these stadia was invariably followed by dormancy in the next stadium. This suggests to the present author an activation-deactivation-reactivation phenomenon based perhaps on fluctuations in the quantity or potency of the diapause-producing factor from above to below the threshold value and back again. [Experimentally produced activation-deactivation-reactivation has been reported for certain cases in plants.]

Bodine & Evans (1931–1934) report that the oxygen consumption and temperature relationships in diapause of wasp larvæ are similar to those in the grasshopper egg. They also report that normal or artifically produced diapause gives marked powers of resistance to or recovery from the harmful effects of immediately preceding x-irradiation. Most noteworthy of all, weak doses at

the beginning of diapause lengthen the period, stronger doses shorten it and still stronger doses break diapause and permit development to proceed although the organism eventually dies from the latent effects of the irradiation. The significance of these data from x-irradiation is not known.

Süffert (1924) reported that the different wing-patterns of spring and summer forms of the butterfly *Araschnia* are due to the fact that the spring form develops from pupæ which undergo a true diapause period whereas the summer form develops from pupæ which do not undergo diapause (see also Heller 1928). The primary difference between spring and summer forms is therefore the type of development—the wing-maculation being only a secondary result (this is true despite the fact that the 'spring form' may also be produced by the action of cold during the sensitive period of wing development of non-diapause pupæ. See Section V-E).

Another peculiarity is that in many species some individuals of a single batch grown under identical conditions will reach the adult stage the first year, others the second year, and others only after several years (Calvert 1929, Faure 1932, Wolcott 1934 and others). It would seem that this is most likely due to differences in the physiological condition of the various individuals caused by differences in genetic constitution.

Whatever the cause of diapause it can frequently be broken by a variety of factors. These may be either environmental factors such as high or low temperature, light or certain chemicals (Readio 1931, Boyce 1931, Bataillon & Su 1931, Bodine *et al.* 1925–1935, Varley & Butler 1933, Sabrosky, Larson & Nabours 1933), friction, electrical or mechanical shocks (Roubaud 1922, Varley & Butler 1933), or parasitism (Salt 1927, Holdaway & Evans 1930, Davies 1930, Cousin 1932, Varley & Butler 1933). Among various Diptera parasitized by Braconids and Chalcids, Varley & Butler (1933) report that there is a striking difference in that in *Lucillia* everything points to the shock of the sting as the causative agent whereas in *Lipara* and *Urophora* the break in larval diapause is not so prompt and must in some obscure way be effected by the parasite itself within the host. The mechanics of how these varied factors operate to break diapause is totally

unknown, and ascribing diapause to hormonal action does little more than furnish a working hypothesis.

The above discussion has been concerned with the physiology of diapause and how it may be broken or prevented. A more or less separate set of data has to do with the experimental production of diapause. In the introductory paragraphs it was pointed out that diapause is an inherent characteristic which might be independent of temperature for its occurrence. That statement may be amplified by saying that when it is experimentally induced by temperature or other means it always differs from hibernation by its obligatory nature.

In the silkworm moth the number of generation a year (voltinism) is controlled by mendelian factors 'maternally' inherited (Uda 1923) but the eggs of the univoltine races incubated at high temperatures almost always produce moths laying non-diapause eggs, and the eggs of bivoltine races incubated at low temperatures usually produce moths laying diapause eggs. Kogure (1933) postulates two interacting substances, one affected by both light and temperature during the egg and less in the larval stages, the other affected by temperature alone during the pupal stage. According to this hypothesis these two substances interact to produce or control both the egg-color and diapause. In connection with this Umeya (1926) has shown by castration followed by ovarian transplantation that the voltinism of the eggs laid by the graft ovaries is absolutely controlled by the genetic constitution of the host regardless of whether uni- or bivoltine. Despite largely negative results from blood transfusion it seems that this (as well as light and temperature control) is an effect of the somatic tissues (via hormones) on the growing oöcytes. It will bear repeating that diapause in the Silkworm is controlled by the action of factors upon the parent, not upon the generation affected. Roubaud (1935) has recently briefly reported a case of diapause in mosquitoes being dependent on the physiological condition of the mother.

Normally emergent forms of the Polyphemus moth can be induced to undergo a pupal diapause by low temperature treatment of the last instar larva or high temperature treatment of the eggs (Dawson 1931). Dormancy can be similarly induced in

larvae of wasps (Bodine & Evans 1934) and mosquitoes (Roubaud 1930).

In closing it might be pointed out that insect diapause is closely paralleled by similar phenomena in fungus spores, plant seeds and buds and even unfertilized animal eggs.

IX. SUMMARY

1. Nymphal and larval ecdysis are both under hormonal control. In the bugs *Rhodnius* and *Triatoma* it has been proved that this hormone is secreted by the corpus allatum, and that its production is controlled by stimulation from the brain. This hormone does not directly cause moulting; it stimulates the ectodermal cells to produce the enzymes that do. (Section III, 1–2.)

2. Nymphal, pupal and adult metamorphosis are also under hormonal control, and the production of the hormone is controlled by stimulation from the brain. The hormone is probably qualitatively difficult from the ecdysis hormone. Several different hormones or quantitative expressions of a single hormone are indicated by the data. In the bugs *Rhodnius* and *Triatoma* the metamorphosis hormone is secreted by the corpus allatum but at a different time from the ecdysis hormone. In these bugs experiments prove that this hormone is an inhibitor, release from which allows metamorphosis to occur. Most insects possess well developed corpora allata but the higher Diptera lack these glands; the source of the hormone in Diptera is not known. (Section III, 3–5.)

The hormonal regulation of development is viewed as due to two competing hormones, one stimulating growth, the other inhibiting metamorphosis.

3. Ripening of eggs by the adults of *Rhodnius* and *Triatoma* is stimulated by another qualitatively different hormone secreted by the corpus allatum. Persistence of the corpus allatum in the adult stage seems to indicate a similar relation in other insects. (Section III, 6.)

4. "Hormones" are also known to affect certain genetic (mendelian) characters. In contrast to the above hormones they appear to be the product of several or all tissues of certain genetic constitution rather than the product of a particular gland. (Section III, 7.)

5. Differentiation in the pupa, as in the embryo, begins in the thorax and proceeds thence anteriorly and posteriorly. This seemingly represents a developmental center with a similar location to that of the differentiation center of the embryo. It is certainly not a function of the nervous system. It seems to partake of the nature of a gradient-field. (Section IV.)

6. The adult eye of hemimetabolous insects, at least of dragonflies, does not develop from the nymphal eye but is composed largely of areas of the head capsule outside the boundaries of the nymphal eye. The insect eye represents a self-differentiating system and is independent of the brain and even of innervation. The anlage is also independent of its position within the body.

The eye, however, does exert an influence on the development of the optic ganglia of the brain.

Almost nothing is known concerning the interdependence of the parts of the central nervous system during differentiation and later development. (Section V, A.)

7. Gonads, genital ducts and secondary sexual characters are almost without exception independent in development. The only clear-cut exception is the testes of *Drosophila* which appear to need contact with the genital ducts for differentiation. (Section V, B.)

8. Insect muscles do not atrophy following severing of their nerves. However, muscles appear in the adult in only those segments in which the ganglia are left intact. Innervation, therefore, is necessary for the differentiation of insect muscles. (Section V, C.)

9. Differentiation of the epidermis may be divided into two subheads: general form and histological structure. In legs of the butterfly *Vanessa* histological structure is determined early and cannot be modified, but general form is determined by the position of the developing limb (data based on operations on third instar larvæ). The differentiation of appendages is independent of their innervation and musculature. These data and heteromorphosis suggest a considerable potency for the presumptive epidermal parts under the control of a gradient-field. The reasons for the differentiation of sclerite and setal patterns are not known (function of position ?). (Section V, D.)

10. The components of the wing-pattern of Lepidotera are relatively independent of one another and of the gross form of the wing and its veins. The parts of the prototype pattern, obtained by purely morphological criteria, have been shown to be physiologically different. These different components have different the 'sensitive periods' (to abnormal environmental factors) and different times of determination, both prior to the development of the pigment. The pattern is restricted to particular places by various morphogenetic processes which control both the structure of the scales produced and the pigment. The determination process may be viewed as a "streaming process," in some cases from the base of the wing distally, in other cases over the central field. The wing pattern includes at least two harmonious-equipotential systems: the central symmetry-system and the eye-spots or ocelli. Both of these are concentric arrangements of zones which after injury show tendencies toward dislocation, fusion and the formation of closed round figures. In *Ephestia* there is a correlation of mitosis-pattern of the anlage with the presumptive dark and light parts of the definitive wing-pattern. (Section V, E.)

11. The presumptive imaginal discs of *Drosophila* are already mapped out at an early embryonic stage. The data concerning their time of determination (chemo-differentiation) are conflicting. The prospective significance and prospective potency of these imaginal discs are practically the same, especially for the thorax and abdomen. (Section V, F.)

12. The above sections on organ development show that the insect body in larval and pupal stages is largely a mosaic of self-differentiating organs and parts except, of course, for the necessity of the developmental hormones. Chemo-differentiation of the anlagen occurs early, usually before or not later than the time of separation of their presumptive anlagen, and the parts differentiate independently according to this determination. The modification of external form of legs, seemingly representing the action of a gradient-field, is an outstanding exception. Section V, G.)

13. Most of the external and certain of the internal organs of nymphs and larvæ are capable of being regenerated. The gonads

and parts of the central nervous system are never regenerated. The power of regeneration becomes greatly reduced in the pupal stage and is almost always absent in the adult (partly a function of age). The quality of the regenerate is usually controlled by the original nature of the organ-stump, and regeneration is usually possible only when a stump of the part remains. Regeneration is independent of the nervous system. Heteromorphic regeneration and certain other points suggest a gradient-field relationship. (Section VI.)

14. Duplications and triplications occur normally or may be induced. In triplications the structures follow Bateson's rule which states that the parts must lie in one plane and that one member is always a mirror-image of the other two. The origin of mirror-image formation is not known.

Anomalies in body-segmentation are common. This is particularly true of the abdomen where determination and differentiation last take place. (Section VII.)

15. Diapause or dormancy is an obligatory phenomenon which seems best viewed as due to either the presence of an inhibitory hormone or the temporary failure of growth hormones. It is manifested as a retardation or cessation of growth, mitosis, metabolism and movements. It may occur normally because of the inherent genetic constitution of the individual, or it may be induced either in the egg by factors in the blood of the mother or in the individual itself after the egg is laid by the action of certain environmental factors. It may be broken (artificially or normally) by a variety of means. It is closely paralleled by similar phenomena in other animals and in plants. (Section VIII.)

X. LITERATURE[11]

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THE GENOTYPES OF THE NORTH AMERICAN HADENINÆ (LEPIDOPTERA, NOCTUIDÆ)

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(*Concluded from page 107*)

Lophoceramica artega Barnes. Fig. 24A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—peaked, not spinose; Marginal spines—a few; Corona—absent; Protuberances—a slender bent rod and a short process ending in a spine; Editum—present; Clavus—rounded; Ædœagus—not ornamented; Vesica—not ornamented.

Tricholita semiaperta Morr. Fig. 28A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Harpe—peaked and spinose; Marginal spines—one; Corona—absent; Protuberances—a curved strap and a smaller strap; Editum—present; Clavus—rounded; Ædœagus—without ornamentation; Vesica—with a single cornutus.

Trichopolia dentatella Grt. Fig. 32A.

Uncus—simple; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—none; Corona—none; Protuberances—an inwardly curved sclerotized bar and a small flat structure produced to a point; Editum—present; Clavus—rounded; Ædœagus—orifice hooked on one side, scobinated on the other; Vesica—with a cornutus.

Group IV

No material available for a study of the male genitalia.

Group V

In the two species included in this group, the harpes are constricted at their proximal portions.

Epia echii Bork. Fig. 49A.

Uncus—cygnated; Peniculus—absent; Scaphium—absent; Subscaphium—slight indication; Harpe—trigonate, spinose;

Marginal spines—absent; Corona—present; Protuberances—a flat lobe rounded at the tip and an irregular hook-shaped structure; Editum—present; Clavus—rounded; Ædœagus—without ornamentation; Vesica—with cornutus; Juxta—present.

Admetovis oxymorus Grt. Fig. 54A.

Uncus—diamond shaped; Peniculus—present; Scaphium—absent; Subscaphium—indications; Harpe—rounded; Marginal spines—present; Corona—present; Protuberances—a chitinous structure rounded at the end; Editum—absent; Clavus—produced, with short bristly hairs on the produced area; Sacculus elongated into a scleritized ridge; Ædœagus—with a cornutus at the base and a slight hook at the orifice; Vesica—with cornutus.

Group VI

Section A

Subsection Ia

Males of *Chabuata ampla* Wlk., *Aletia vitellina* Hub., and *Meterana pictula* White were not available for study, so cannot be included in the following discussion.

In this subsection there are eight genera whose relationships are not easy to determine. They seem to have much in common and structurally they overlap each other. If one may rely on the structure of the male genitalia to indicate relationships, then they can be grouped as follows:

(1) Ulolonche, Zosteropoda, and Neleucania
(2) Melanchra and Hyssia
(3) Ceramica (4) Hyphilare (5) Anarta

On this basis only one genus may be considered synonymic—*e.g.* Hyssia with Melanchra.

Ulolonche niveiguttata Grote. Fig. 84A.

Uncus—simple; Peniculus—absent ?; Scaphium—absent; Subscaphium—absent; Harpe—peaked, spinose; Marginal spines—absent; Corona—absent; Protuberance—a membraneous fold and a long surved bar; Editum—present; Clavus—rounded; Ædœagus—without ornamentation; Vesica—with rows of teeth.

Zosteropoda hirtipes Grote. Fig. 91A.

Uncus—forked; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—present; Corona—absent; Protuberance—a curved strap; Editum—present; Clavus—produced and bearing a few bristly hairs; Ædœagus—without ornamentation; Vesica—bearing several small spines, one bulbed cornutus, and a small cornutus without a bulb.

Neleucania niveicosta Smith. Fig. 95A.

Uncus—forked; Peniculus—present; Scaphium and Subscaphium—absent; Harpe-rounded; Marginal spines—present; Corona—absent; Protuberances—half-way up the harpe a long curved spine, at the base a smaller curved spine; Editum—present?; Clavus—produced and bearing a few hairs; Ædœagus—with one large spine; Vesica—with several small spines.

Melanchra persicariæ Linn. Fig. 58A.

Uncus—tongue shaped; Peniculus—absent; Scaphium—absent; Subscaphium—large, diamond shaped; Harpe—trigonate, spinose; Marginal spines—absent; Corona—absent; Protuberance—a fold in the harpe; Editum—present; Clavus—produced, scobinated; Ædœagus—orifice with two lateral spines; Vesica—with cornutus.

Hyssia cavernosa Eversm. Fig. 65A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonate, spinose; Marginal spines—a few; Corona—present; Protuberances—an irregular sclerotized ridge ending in a protruding disc; Editum—present; Clavus—rounded; Ædœagus—orifice provided with a ventral and lateral hook; Vesica—not ornamented.

Ceramica picta Harris. Fig. 72A.

Uncus—knobbed; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked and spinose, the dorsal border with two thumb-like projections; Marginal spines—absent; Corona—absent; Protuberances—a mere thickening of the wall of the sacculus; Editum—present; Clavus—rounded; Ædœagus—orifice provided with lateral hooks; Vesica—not ornamented.

Hyphilare albipuncta Schiff. Fig. 69A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—present; Corona—absent; Protuberances—a distorted "Y" shaped structure, one arm of the "Y" broad and the other narrow. There is also a curved spine; Editum—present ?; Clavus—produced; Ædœagus—without ornamentation; Vesica—without ornamentation.

Anarta myrtilli Linn. Fig. 76A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—asymmetrical, rounded; Marginal spines— ; Corona— ; Protuberances—left clasper a rough tapered arm, right clasper much larger produced into a peaked, flattened plate; Editum— ; Clavus—rounded; Ædœagus— ; Vesica—with a large bulbed cornutus.

Subsection Ib

In this subsection there are fourteen genotypes but the males of four of them were not available for a study of their genitalia. These were *Dargida grammivora* Wlk. (*gramminivora* Wlk.), *Eriopyga punctulum* Gn., *Naesia moesta* Wlk., and *Borolia furcifera* Moore. The last three were placed in the same group with Meliana. Meliana is the only genotype of the group of which males were available. Whether male genitalia can be used to tie these four genotypes together cannot be determind until these structures have been studied in the other three genotypes. *Dargida gramminivora* Wlk. is the only species lacking in the "Hadena" group. On the bases of other characters, the eight genotypes of this group tie up very well but as soon as a study of the male genitalia is made the linkage does not seem so close. The "Hadena" group breaks up in such a way that Hadena is associated only with Aethria, Astrapetis and possibly Diataraxia. Even here one may have to stretch a point to keep the group together. The other five genotypes on the basis of their male genitalia are independent entities. At this point we are face to face with the question whether we should group these fourteen genotypes together because of similarity in frons, antennæ and

other similar structures or should they be split because their male genitalia show such differences.

I have chosen to keep them together because the male genitalia of other congeneric species must be studied before we can determine what genital characters are of generic value. The differences we note now may be specific and not generic.

Meliana flammea Curt. Fig. 143A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded; Marginal spines—present; Corona—absent; Protuberances—a tripartate organ, the inner lobe club shaped provided with a few spines; the middle a simple rod; the outer broad and flat; Editum—present, prominent; Clavus—irregular; Ædœagus—without ornamentation; Vesica—provided with a bunch of teeth and a row of small spines.

Heliophila pallens Linn. Fig. 147A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded and spinose; Marginal spines—present; Corona—absent; Protuberances—a stout curved strap and a slender rod; Editum—present; Clavus—slightly rounded; Ædœagus—without ornamentation; Vesica—with a band of teeth.

Pseudorthodes vecors Gn. Fig. 131A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, not spinose; Marginal spines—absent; Corona—absent; Protuberances—a large curved strap; Editum—absent; Clavus—rounded; Ædœagus—without ornamentation; Vesica—with cornutus.

Hadena cucubali Schiff. Fig. 99A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent ?; Corona—absent; Protuberances—a fold and a papilla from the base of the cucullus; Editum— ; Clavus—strongly scobinated; Ædœagus—with serrations at the orifice and extending along the vesica.

Aethria serena Schiff. Fig. 103A.

Uncus—tongue shaped; Peniculus—present; Scaphium—absent; Subscaphium—slight indications; Harpe—rounded; Marginal spines—few; Corona—present; Protuberances—a broad and flattened strap rounded at its tip; also a chitinous ridge; Editum—present; Clavus—strongly produced; Ædœagus—orifice with a lateral hook; Vesica—with a cornutus.

Astrapetis dentina Schiff. Fig. 107A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—few; Corona—present; Protuberances—a chitinous ridge above which there is a flat strap ending in a round curved head; Editum—present; Clavus—rounded; Ædœagus—orifice with a long lateral hook; Vesica—with a cluster of spines.

Diataraxia splendens Hub. Fig. 110A.

Uncus—simple and covered with spines; Peniculus—present; Scaphium—absent; Subscaphium—consists of two or more chitinous bands; Harpe—rounded; Marginal spines—absent; Corona—present; Protuberances—a chitinous thickening with a slender spine. There is also a bipartate organ, one part of which is a rounded lobe and the other a short pointed rod; Editum—present; Clavus—slightly produced and bearing a few bristles; Ædœagus—orifice without ornamentation; Vesica—with two lobes, one bearing a large bulbed cornutus, the other with a small bulbed cornutus.

Eupsephopaectes procinctus Gr. Fig. 117A.

Uncus—diamond shaped; Peniculus—present; Scaphium—absent; Subscaphium—absent; Harpe—trigonate; Marginal spines—absent; Corona—present; Protuberances—a very slender much curved rod bearing a few bristles at its tip. There is also a sharp, stout hook; Editum— ; Clavus—scobinated; Ædœagus—without ornamentation; Vesica—without ornamentation.

Crocigrapha normani Grt. Fig. 120A.

Uncus—simple; Peniculus—present; Scaphium—absent; Subscaphium—indicated; Harpe—rounded, spinose; Marginal spines

—present; Corona—present; Protuberances—a flat "Y" shaped organ, one arm of which bears bristly hairs. There is also a curved rod terminating in a point; Editum—poorly developed; Clavus—produced; Ædœagus—orifice scobinated on one side; Vesica—with a bulbed cornutus.

Aplecta nebulosa Hufn. Fig. 124A.

Uncus—simple; Peniculus—indicated; Scaphium and Subscaphium—absent; Harpe—trigonate, spinose. One angle is produced and bears a spine; Marginal spines—present; Corona—present; Protuberances—the sacculum provided with a terminal prominence which is spinose. The inner edge of the sacculus is very irregular, more so on the right side. On the right side there is also a curved hook hidden in the figure by the large spines. On the left side there is another more irregular hook and a small strap like projection slightly knobbed at its tip; Editum—present?; Clavus—very irregular; Ædœagus—without ornamentation; Vesica—without ornamentation.

Subsection II

There are twelve genotypes in this section, and all twelve are figured. They have so little in common with each other that there is no way to group them. There are two species which the writer expected to exhibit similar genital characters. These are *Nephelodes emmedonia* Cram. (*minians* Gn.) and *Monostola asiatica* Alph. Superficially they strongly resemble each other but their male genitalia would not indicate close relationship. Here is a place where the male genitalia may be of specific rather than generic value.

Morrisonia evicta Grt. Fig. 151A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—almost trigonate; Marginal spines—present; Corona—present; Protuberances—a very slender chitinous rod and a large curved strap; Editum—absent; Clavus—rounded; Ædœagus—without ornamentation; Vesica—without ornamentation.

Xylomyges conspicillaris Linn. Fig. 155A.

Uncus—slightly cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—truncate, not spinose; Marginal

spines—present; Corona—absent; Protuberances—an irregular chitinous ridge in a small rod, also a prominent curved hook; Editum—indicated; Clavus—produced; Ædœagus—without ornamentation; Vesica—with a row of teeth and an irregular hook.

Himella fidelis Grt. Fig. 159A.

Uncus—simple; Peniculus—absent; Scaphium and Subscaphium—absent; Harpe—truncated, with the edges bordered, some spines present; Marginal spines—absent; Corona—absent; Protuberances—a small chitinous projection bearing a short papilla provided with spines and a small pointed projection. There is also a very long chitinous rod ending in a small spine; Editum—absent; Clavus—rounded; Ædœagus—not ornamented; Vesica—not ornamented.

Alysia specifica Gn. Fig. 163A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—present; Protuberances—two flat straps turned out at their tips; Editum—absent; Clavus—rounded?; Ædœagus— ; Vesica— .

Hyperepia jugifera Dyar. (pi. B. & L.). Fig. 167A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a somewhat hooked shaped spine and a smaller curved chitinous protuberance; Editum—present; Clavus—rounded; Ædœagus—with one stout spine and two clusters of smaller spines. One cluster lies dorsad and the other laterad and on the opposite side from the stout spine; Vesica—without ornamentation.

Nephelodes emmedonia Cram. (*minians* Gn.). Fig. 171A.

Uncus—spoon shaped; Peniculum—present; Scaphium and Subscaphium—absent; Harpe—rounded with pollex that bears two small spines at its tip. Spinose; Marginal spines—present; Corona—absent; Protuberances—a flat curved strap. The one on the right side longer. There is also another flat strap rounded

at its tip; Editum—present; Clavus—scobinated; Ædœagus—without ornamentation; Vesica—without ornamentation.

Monostola asiatica Alph. Fig. 175A.

Uncus—broad with tip truncated; Peniculum—present; Scaphium and Subscaphium—absent; Harpe—rounded, hardly spinose; Marginal spines—absent; Corona—present; Protuberances—an incurved organ roughened at its tip; Editum—present; Clavus—scobinated; Ædœagus—without ornamentation; Vesica—without ornamentation.

Charaeas cespitis Denn. & Schiff. Fig. 179A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—more or less truncated, spinose; Marginal spines—absent; Corona—absent; Protuberances—a flattened organ with its free edge curved; Editum—present; Clavus—rounded; Ædœagus—without ornamentation; Vesica—with a large cornutus and a roughened area.

Haderonia subarschanica Staud. Fig. 182A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonate, spinose with a larger spine; Marginal spines—present; Corona—present; Protuberances—a weak chitinous bar and a small tubercle; Editum—absent; Clavus—rounded; Ædœagus—without ornamentation; Vesica—without ornamentation.

Epineuronia popularis Fab. Fig. 186A.

Uncus—spatulate; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked, hairy, and with a pollex; Marginal spines—present; Corona—absent; Protuberances—a flattened curved lobe which appears to be pointed when viewed from the side; Editum—present; Clavus—rounded; Ædœagus—a band of teeth near the orifice; Vesica—roughened.

Acerra normalis Grt. Fig. 190A.

Uncus—broad, diamond shaped at tip; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked; Marginal spines—few; Corona—absent; Protuberances—a small scobinated tubercle and a rough bar bent at an angle; Editum—absent;

Clavus—rounded; Ædœagus—orifice with two scobinated ridges; Vesica—not ornamented.

Stretchia plusiaeformis Hy. Edw. Fig. 194A.

Uncus—simple; Peniculus—present ?; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a chitinous thickening and a slender curved bar; Editum—present; Clavus—rounded; Ædœagus—not ornamented; Vesica—scobinated and with a cornutus.

Section B

Subsection Ia

There are five genotypes in this subsection and the male genitalia of all of them are figured. It has been previously stated that Perigrapha resembles both Acerra and Stretchia. If one compares their male genitalia with that of Perigrapha, no resemblance can be seen. On the other hand, Eurypsyche has been separated from Meliana on the bases of frons and other characters but the male genitalia of the two genotypes have much in common. Further morphological studies on related species are needed to clear up some of these points of relationship.

Perigrapha i-cinctum Denn. & Schiff. Fig. 198A.

Uncus—broad, diamond tip; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonate, spinose with one tip produced forming a protuberance which bears a tuft of marginal spines; Marginal spines—present; Corona—absent; Protuberances—a very small projection bearing a few stiff bristles, and a curved strap which may or may not be roughened along one edge; Editum—present; Clavus—rounded; Ædœagus—without ornamentation; Vesica—without ornamentation.

Xylomania hiemalis Grt. Fig. 202A.

Uncus—a knobbed tongue; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—peaked; Marginal spines—few; Corona—indicated; Protuberances—a very small chitinous spine and also another curved spine—Editum—present; Clavus—rounded; Ædœagus—not ornamented; Vesica—with a scobinated ridge and two small spines.

Engelhardtia ursina Smith. Fig. 206A.

Uncus—cygnated; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—broad, flattened at its apex with an indication of a pollex, not spinose; Marginal spines—absent; Corona—absent; Protuberances—a chitinous hook hardly free, and a curved spine; Editum—present; Clavus—rounded; Ædœagus—not ornamented; Vesica—with cornutus.

Lasiestra phoca Moschl. Fig. 210A.

Uncus—tongue shaped; Peniculus— ; Scaphium and Subscaphium—absent; Harpe—rounded; Marginal spines—few; Corona—present; Protuberances—a curved claw turned inward, and a shorter curved bar turned outward; Editum—absent; Clavus—rounded, almost produced; Ædœagus—not ornamented; Vesica—with two small cornuti.

Eurypsyche similis Butler. Fig. 214A.

Uncus—tongue shaped; Peniculus—present ?; Scaphium and Subscaphium—absent; Harpe—rounded, spinose, slightly pointed; Marginal spines—absent ?; Corona—absent; Protuberances—three curved processes; Editum— ; Clavus—rounded; Ædœagus—not ornamented; Vesica—with a row of very large teeth.

Subsection Ib

There are seven genotypes in this section one of which—*Scotogramma submarina* Grt.—is not figured on the plates of male genitalia. Only two of the remaining six show any resemblance. There are *Barathra albicolon* Ochs. and *Neuria reticulata* Linn.

Cardepia irrisor Ersch. Fig. 218A.

Uncus—spatulate; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent ?; Corona—present; Protuberances—a broad chitinous organ somewhat pointed at its tip; Editum— ; Clavus—concave on one side, irregular on the other; Ædœagus— ; Vesica—

Trichocosmia inornata Grt. Fig. 222A.

Uncus—spatulate; Peniculus—absent ?; Scaphium and Subscaphium—absent; Harpe—peaked; Marginal spines—present,

some of which are very stout; Corona—absent; Protuberances—a very slight fold near the apex of each harpe, and the right harpe bears a club shaped organ with small teeth at its tip; Editum—absent; Clavus—more or less rounded; Ædœagus—bears a single spine; Vesica—spined.

Barathra albicolon Ochs. Fig. 226A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonate, spinose; Marginal spines—present; Corona—present; Protuberances—a flat, slightly scobinated strap above which is a more slender curved organ; Editum—present; Clavus—produced; Ædœagus—orifice with a hook on one side, and a band of teeth; Vesica—with a band of teeth.

Neuria reticulata Vill. (griseo-reticulata Retzius). Fig. 242A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—trigonate, spinose; Marginal spines—present; Corona—present; Protuberances—a chitinous flap, a ridge, and a small curved bar; Editum—present; Clavus—scobinated; Ædœagus—orifice with a hook; Vesica—with a band of small teeth.

Dianthoecia carpophaga Bork. Fig. 234A.

Uncus—simple; Peniculus—absent; Scaphium and Subscaphium—absent; Harpe—small, rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a small, flat lobe with rounded tip, and a chitinous fold; Editum—present; Clavus—rounded; Ædœagus—with two scobinated lobes, one on each side; Vesica—with a small bulbed cornutus.

Sideridis evidens Hub. Fig. 238A.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—few; Corona—present; Protuberances—a curved strap slightly rough at its tip; Editum—present; Clavus—produced; Ædœagus—not ornamented; Vesica—not ornamented.

Subsections IIa and IIb

In these two sections there are seven genotypes. The male genitalia of five of these are figured. The two not illustrated are

Craterestra lucina Druce, and *Discestra chartaria* Grt. All seven genotypes can be readily separated on the basis of their frons and antennæ and the genitalia of those which have been studied show enough differences to warrant their separation.

Xanthopastes timais Cram. Fig. 246A.

Uncus—large, bilobed, spinose; Peniculum— ; Scaphium and Subscaphium—absent; Harpe—truncated; spinose; Marginal spines—absent; Corona—present; Protuberances—on the left harpe only a flat, rounded, spinose projection; Editum— ; Clavus—rounded, very spinose; Ædœagus—not ornamented?; Vesica—with a cornutus and many small spines.

Cea immacula Grt. Fig. 266A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—few present; Corona—absent; Protuberances—a strongly bent chitinous strap; Editum—present; Clavus—rounded; Ædœagus—the base provided with a long hook; Vesica—not ornamented.

Trichoclea decepta Grt. Fig. 8B.

Uncus—simple; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—absent; Protuberances—a strap rounded at its tip, also a chitinous ridge hardly free and with a waved edge (two views are shown of this structure in the figure); Editum—absent; Clavus—produced, more on the right side. Both sides with bristles on the rounded portion; Ædœagus—scobinated on one side; Vesica—without ornamentation.

Ichneutica ceraunias Meyrick. Fig. 250A.

Uncus—tongue shaped; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, spinose; Marginal spines—absent; Corona—present; Protuberances—a flat, chitinous organ drawn to a point and bearing transverse ridges; Editum—absent; Clavus—rounded; Ædœagus—not ornamented; vesica—not ornamented.

Miodera stigmata Smith. Fig. 262A.

Uncus—slender, diamond tip; Peniculus—present; Scaphium and Subscaphium—absent; Harpe—rounded, not spinose; Mar-

ginal spines—absent; Corona—present; Protuberances—a broad, flat hook and a chitinous thickening hardly free at its tip; Editum —present; Clavus—rounded; Ædœagus—orifice with a single cornutus; Vesica—with a large cornutus ?.

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CONCLUSION

The reader may notice that there are a few Hadenine genotypes which are not mentioned in this paper. The omissions are due to the lack of material. These omissions are few in number and it seemed best not to delay publication on their account, especially since there was no assurance that the gaps could be quickly filled.

These needed species, when available, will form the basis for a short supplement to this article. Polia has been omitted because its type, flavicincta, is not a Hadenine and therefore cannot replace either Mamestra or Hadena.

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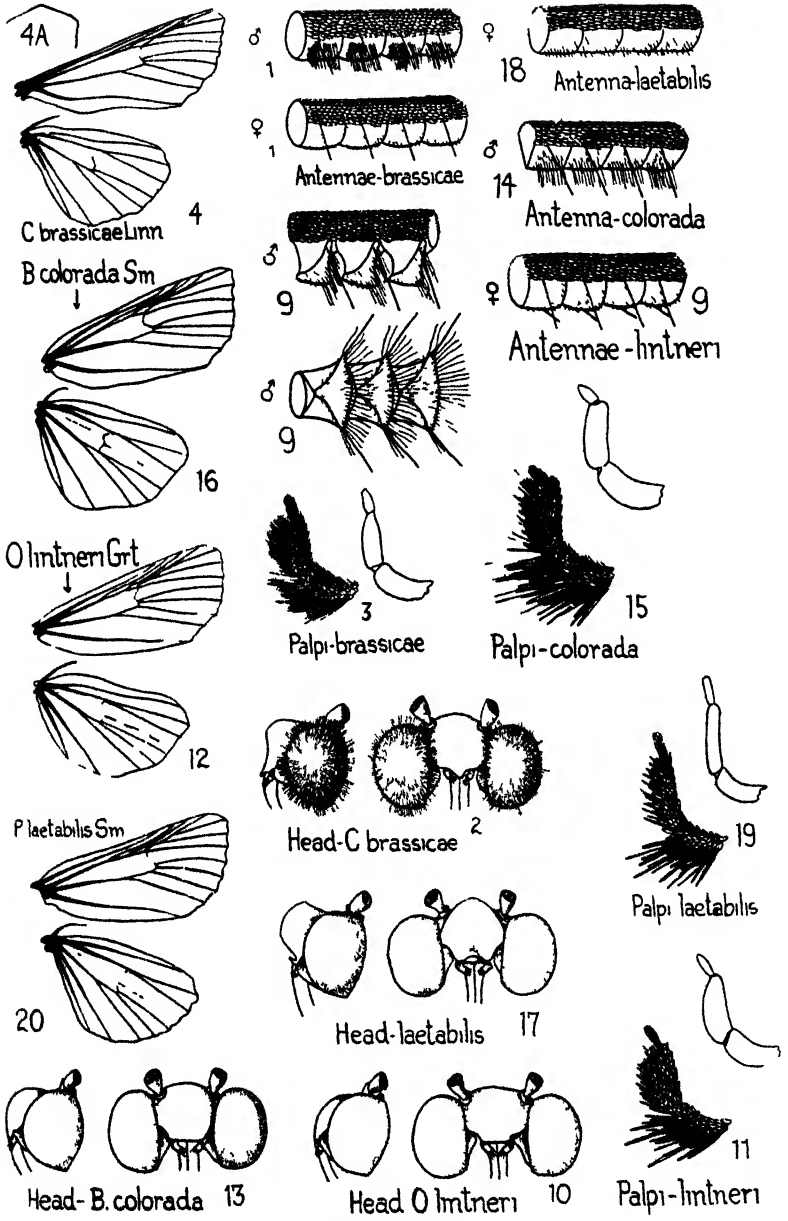
4A
C brassicae Linn 4
B colorada Sm
16
O lintneri Grt
12
P laetabilis Sm
20
♂ 1
♀ 1
Antennae-brassicae
♂ 9
♂ 9
♀ 18
Antenna-laetabilis
♂ 14
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9
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15
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19
Palpi laetabilis
Head-laetabilis 17
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Head O lintneri 10

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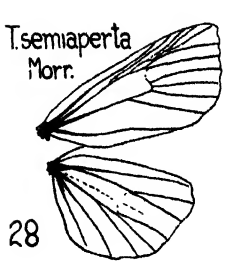
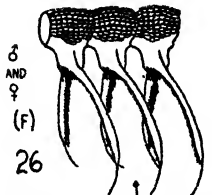
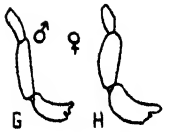




(F)&(G) Antennae-semiaperta



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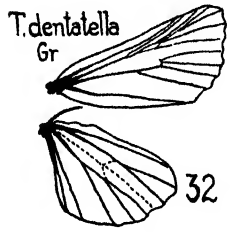

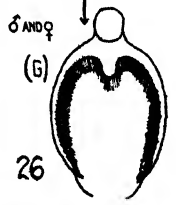

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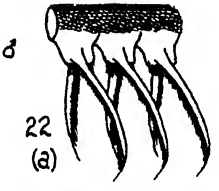
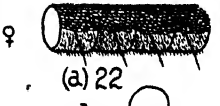
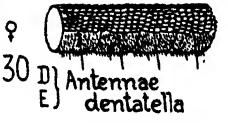
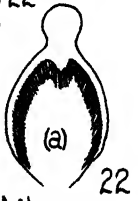


Palpi-artega

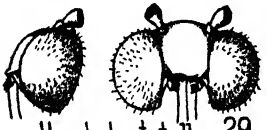


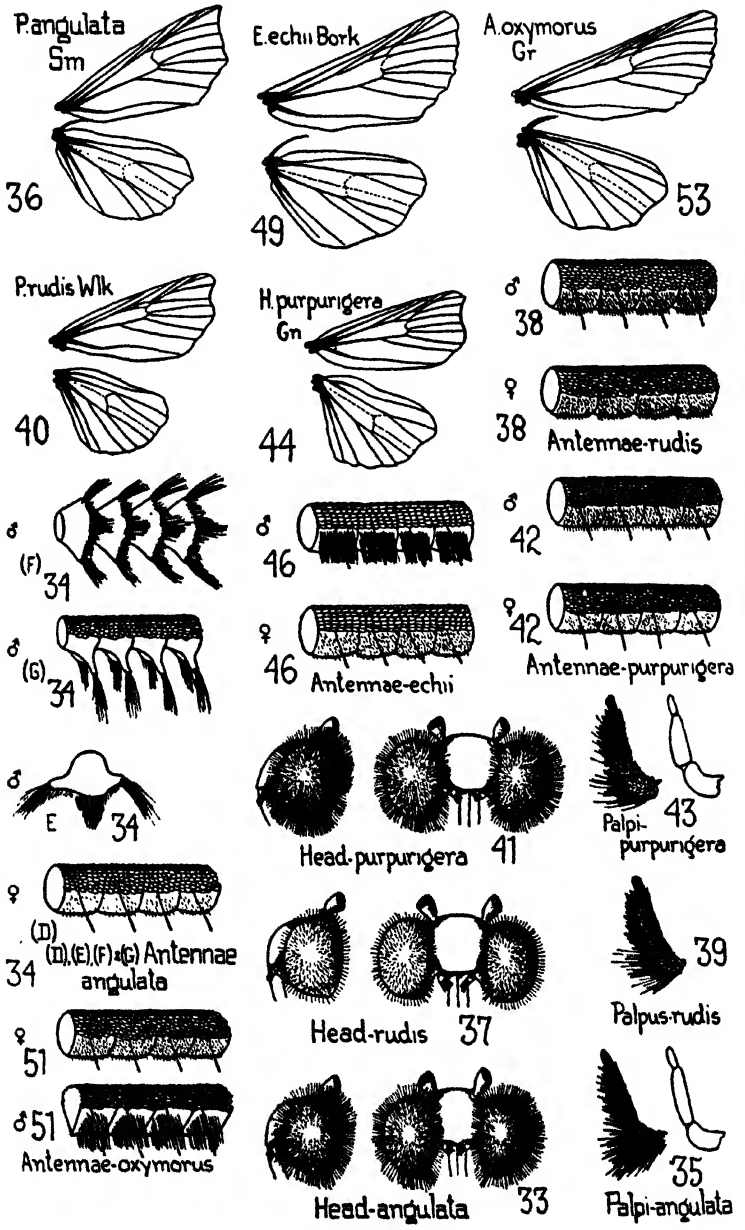




Antennae-(a)-artega

Head-artega

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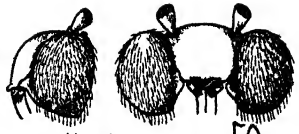
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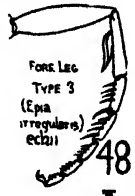
Palpi-oxymorus



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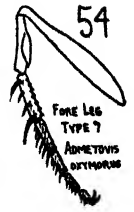

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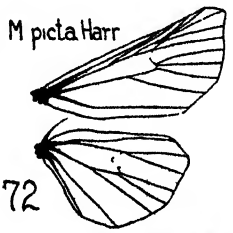
69


M picta Harr
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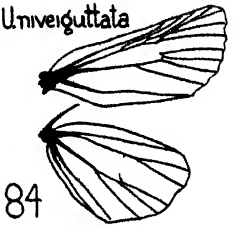
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Head albipuncta 66

Head-picta

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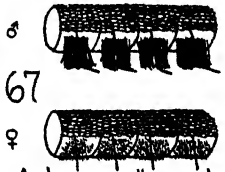
Antennae-albipuncta

83
Palpi-niveiguttata

Head niveiguttata 81

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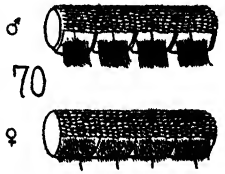
♀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Palpi-picta 71

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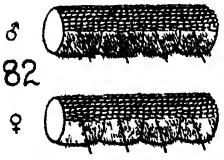
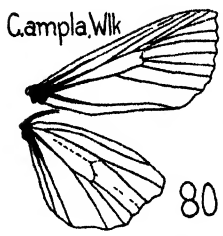
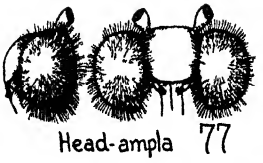
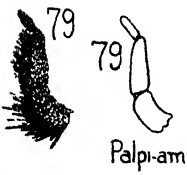

Antennae niveiguttata

68
Palpi-albipuncta


C ampla Wlk
♀
80


Head-ampla 77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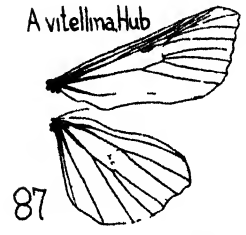
79
Palpi-ampla


A vitellina Hub
87

Head vitellina 85

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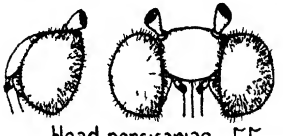
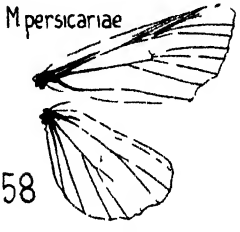
Palpi-pictula

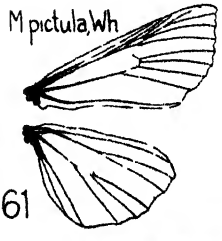

Head persicariae 55
Head-pictula

86
Palpi-vitellina


M persicariae
58

62 Head-cavernosa

57
Palpi-persicariae


M pictula Wh
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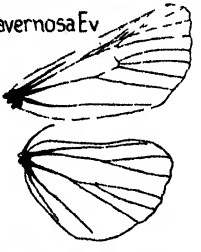
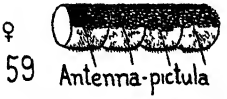

H cavernosa Ev
65

64
Palpi-cavernosa

♂
56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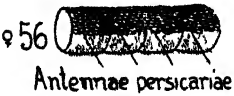
59 Antenna-pictula

♂
63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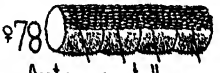
Antennae persicariae


♀78
Antenna vitellina
Antenna-ampla

♀63
Antennae-cavernosa,

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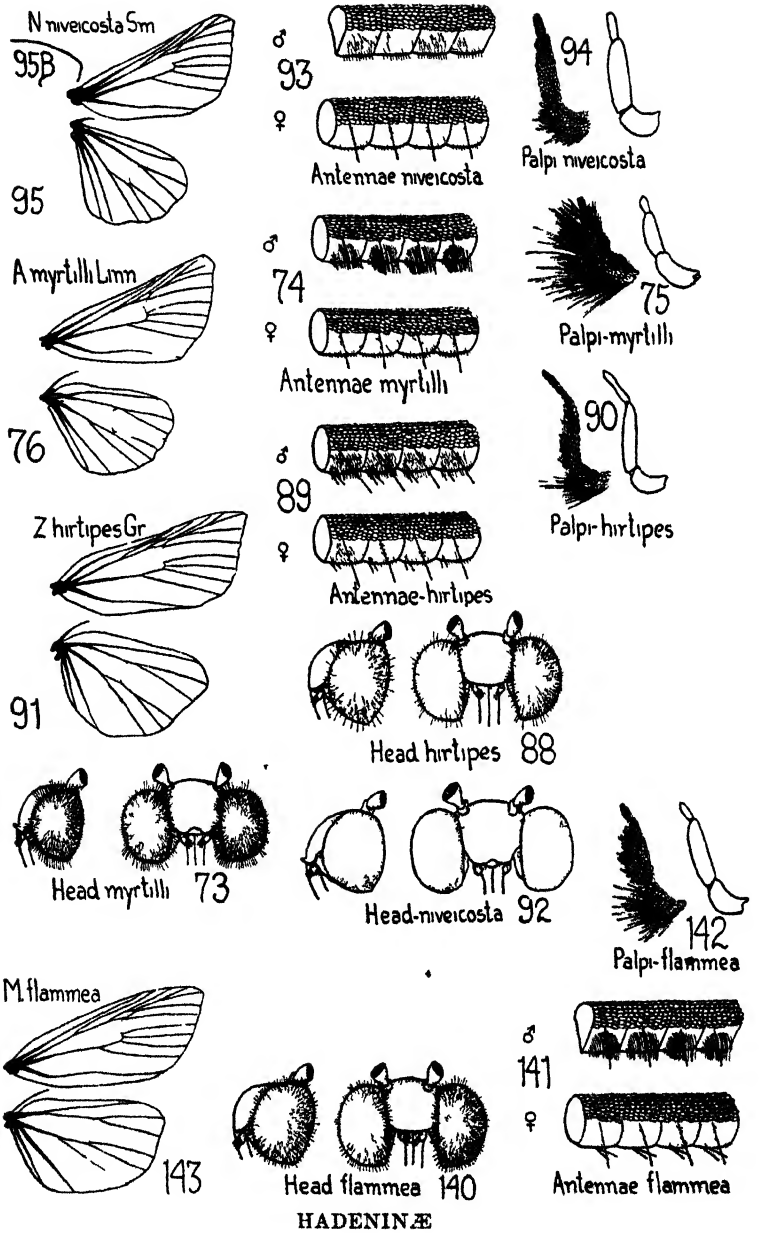
N niveicosta Sm
95β
95
♂
93
♀
Antennae niveicosta
94
Palpi niveicosta
A myrtilli Linn
76
♂
74
♀
Antennae myrtilli
75
Palpi-myrtilli
Z hirtipes Gr
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♂
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Palpi-hirtipes
Head hirtipes 88
Head myrtilli 73
Head-niveicosta 92
142
Palpi-flammea
M flammea
143
Head flammea 140
♂
141
♀
Antennae flammea

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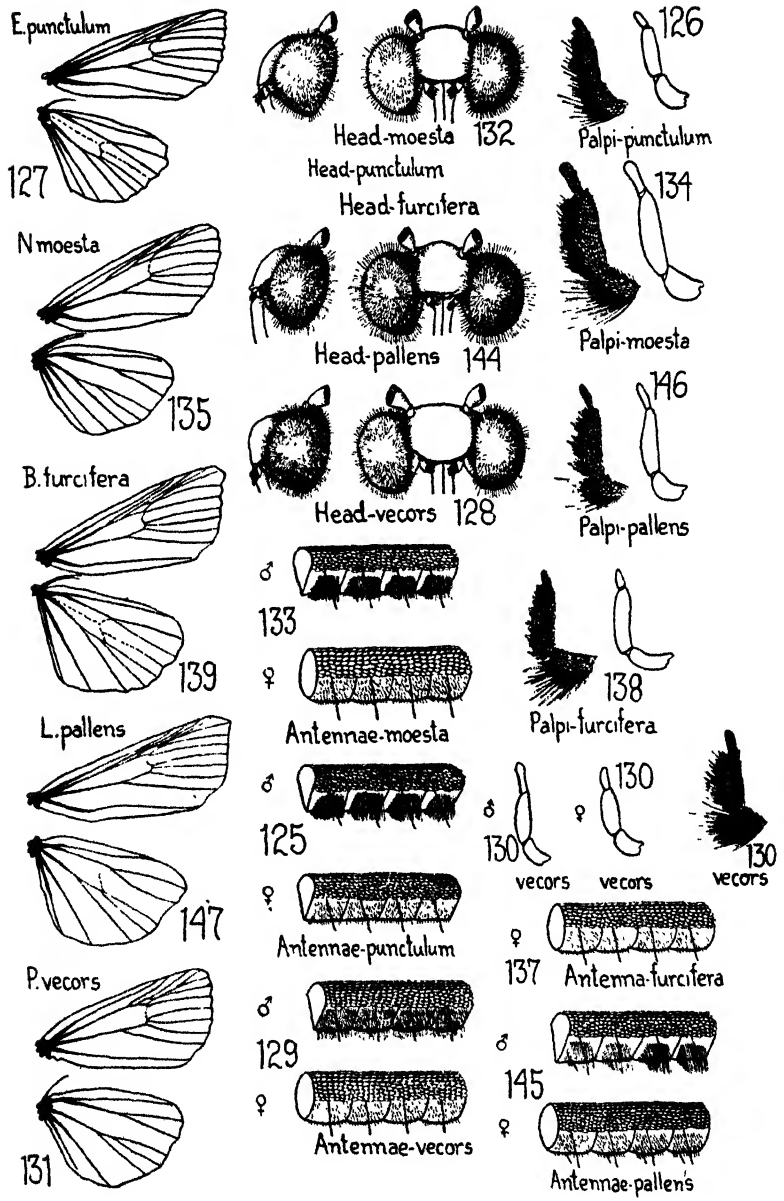
E.punctulum
127
Head-moesta 132
Head-punctulum
Head-furcifera
126
Palpi-punctulum
N.moesta
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Head-pallens 144
134
Palpi-moesta
B.furcifera
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Head-vecors 128
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♂
133
♀
Antennae-moesta
138
Palpi-furcifera
L.pallens
147
♂
125
♀
Antennae-punctulum
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130
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130
vecors
vecors
130
vecors
♀
137
Antenna-furcifera
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145
♀
Antennae-pallens

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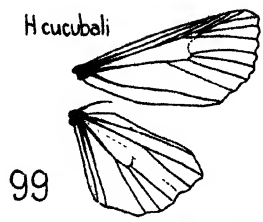
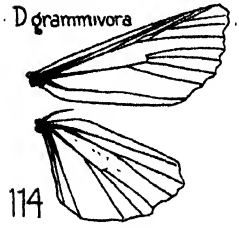
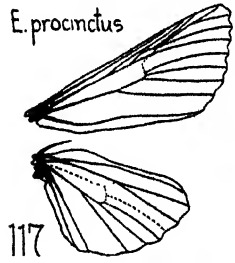
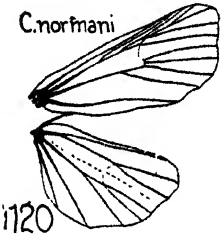
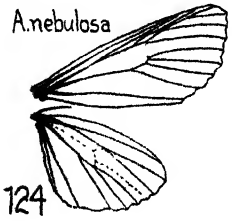
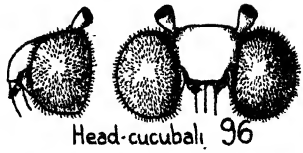


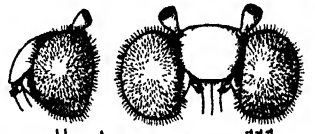




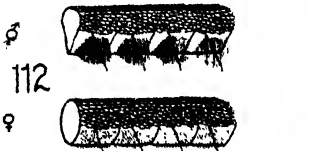


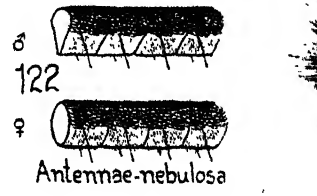


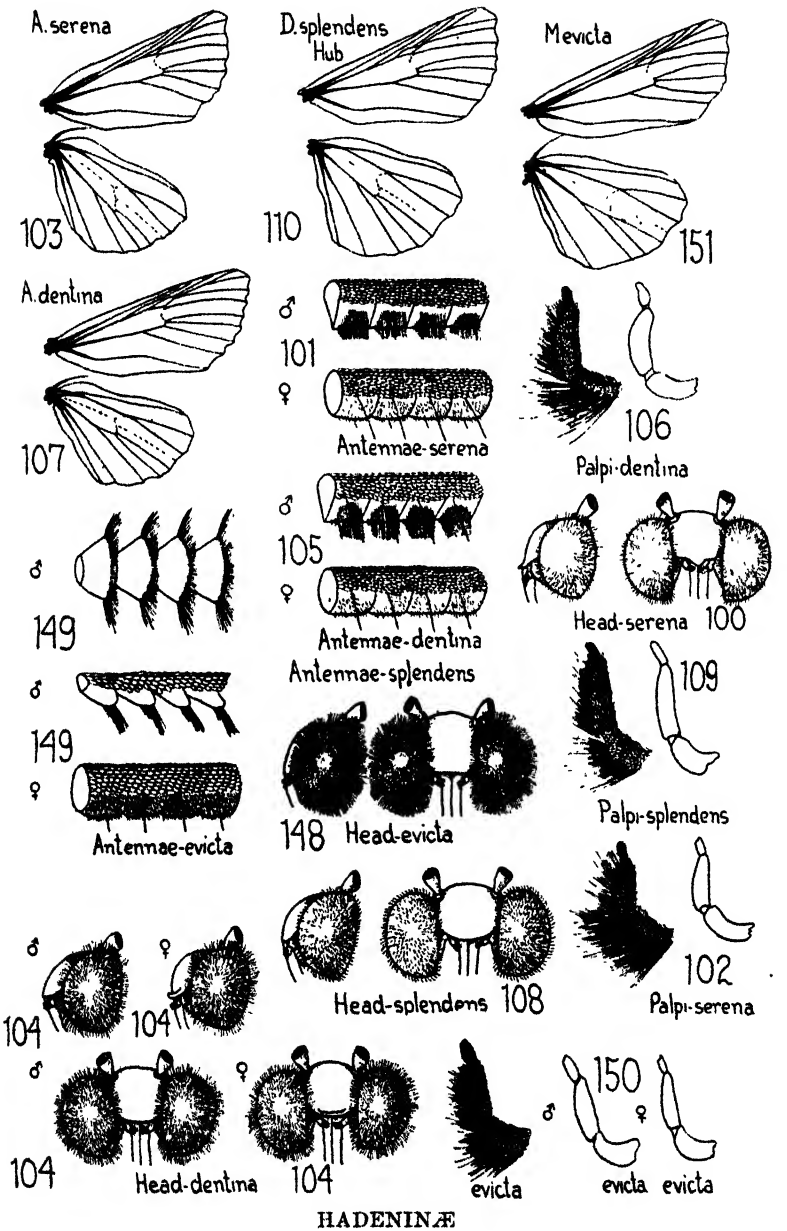




Head-procinctus






A. serena
103
D. splendens Hub
110
Mevicta
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A. dentina
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♂
101
♀
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Palpi-dentina
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evicta
♂ ♀
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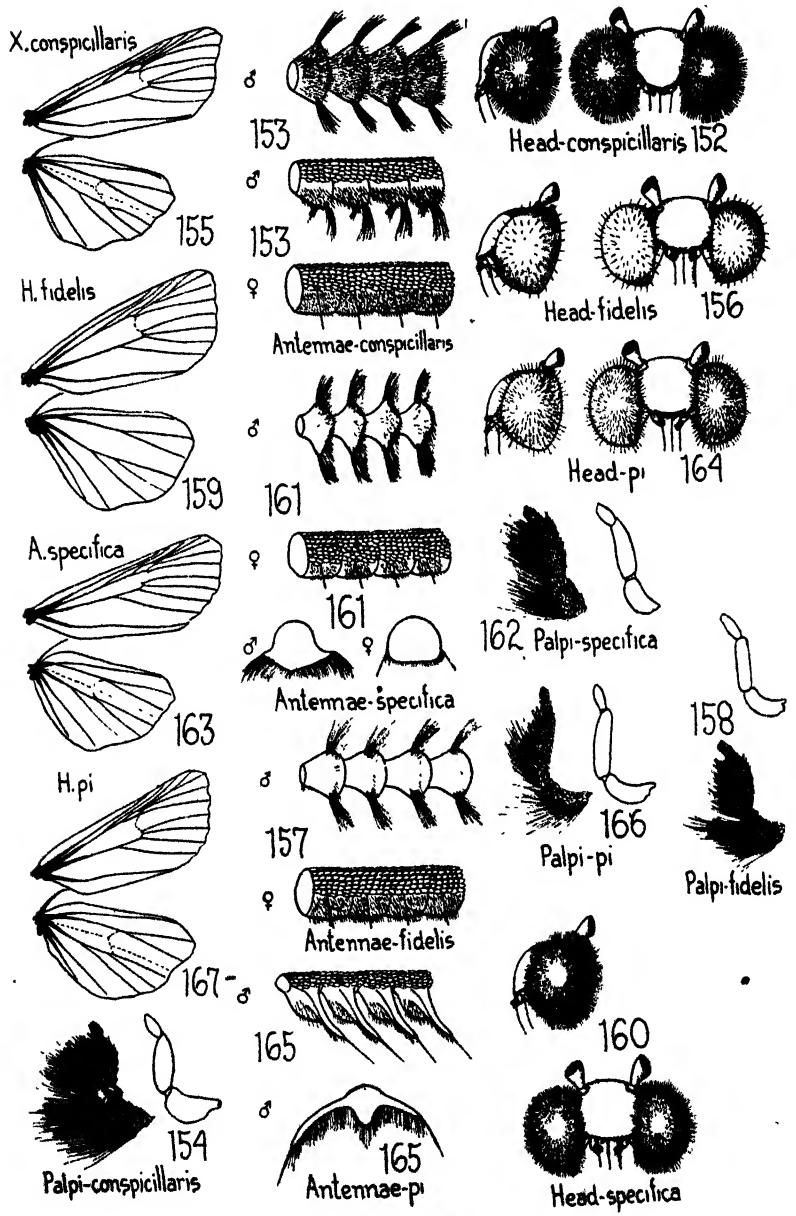
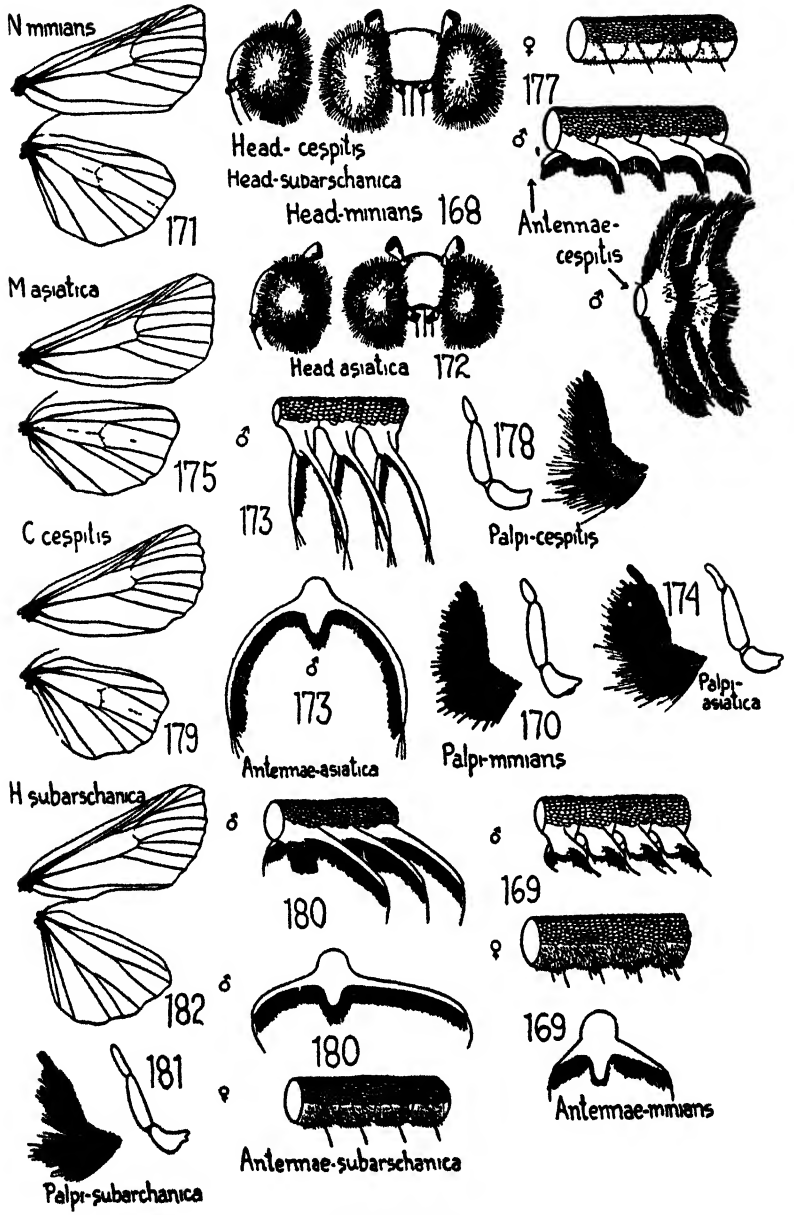
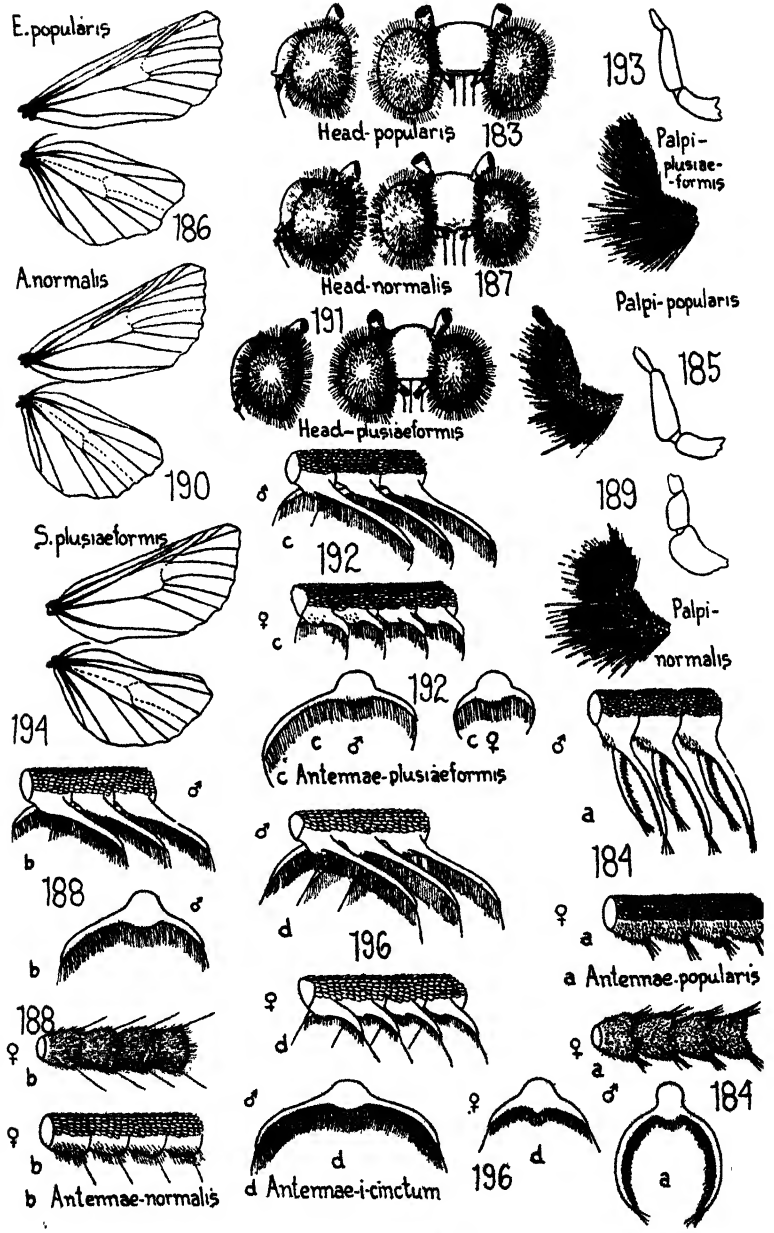
evicta evicta

HADENINÆ

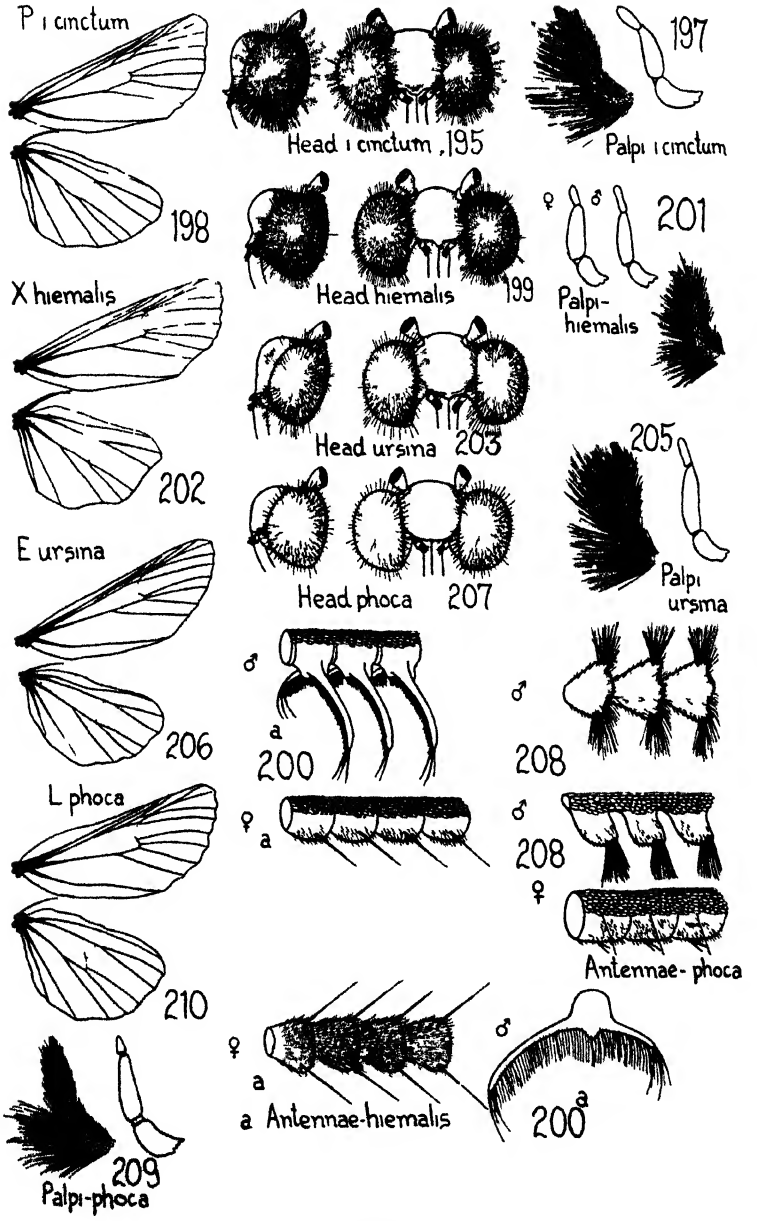

X.conspicillaris
155
♂
153
♂
153
♀
Antennae-conspicillaris
Head-conspicillaris 152
Head-fidelis 156
H.fidelis
159
♂
161
Head-pi 164
A.specifica
163
♀
161
♂ ♀
Antennae-specifica
162 Palpi-specifica
158
H.pi
♂
157
♀
Antennae-fidelis
166
Palpi-pi
Palpi-fidelis
167
♂
165
160
154
Palpi-conspicillaris
♂
165
Antennae-pi
Head-specifica

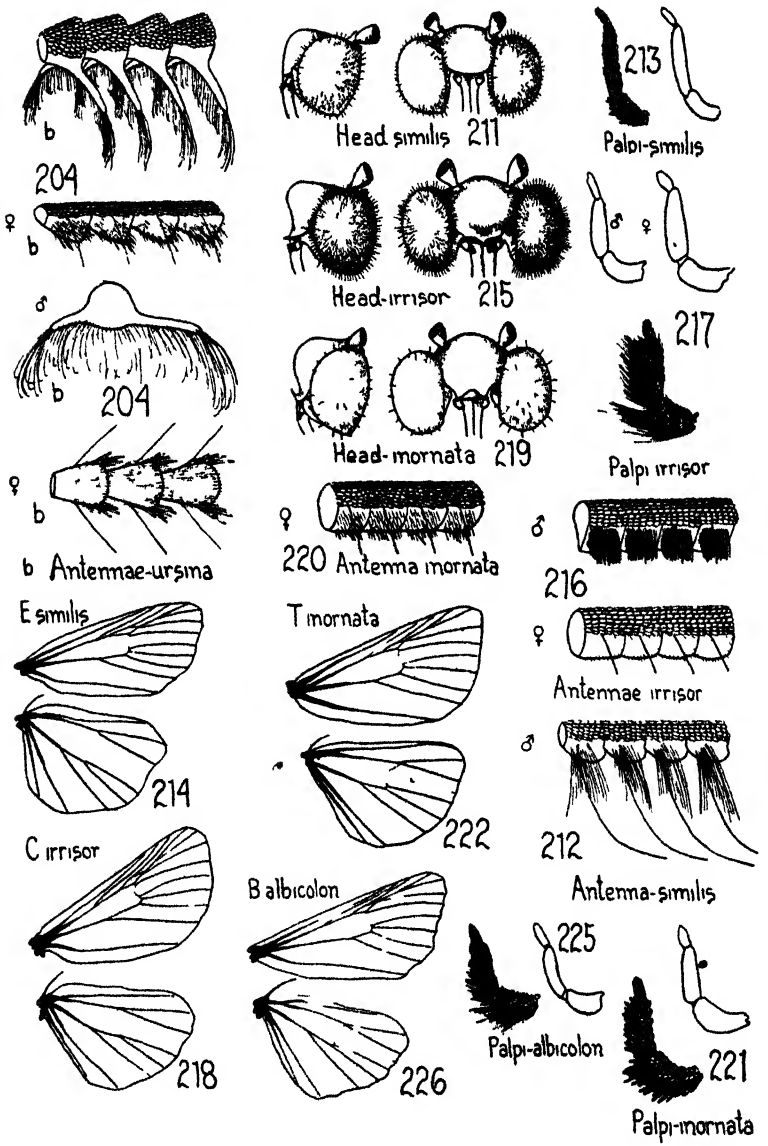
HADENINÆ


N mmians
171
Head- cespitis
Head-subarschanica
Head-mmians 168
♀
177
♂
Antennae-
cespitis
♂
M asiatica
175
Head asiatica 172
♂
173
178
Palpi-cespitis
C cespitis
179
♂
173
Antennae-asiatica
170
Palpi-mmians
174
Palpi-
asiatica
H subarschanica
182
♂
180
♂
169
♀
♂
180
169
♀
181
Palpi-subarchanica
Antennae-subarschanica
Antennae-mmians

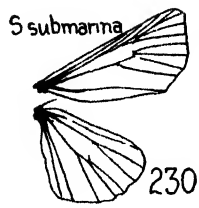

E. popularis
186
A. normalis
190
S. plusiaeformis
194
188
188
b Antennae-normalis
Head-popularis 183
Head-normalis 187
191
Head-plusiaeformis
192
192
c Antennae-plusiaeformis
196
d Antennae-i-cinctum
196
193
Palpi-plusiae-formis
Palpi-popularis
185
189
Palpi-normalis
184
a Antennae-popularis
184

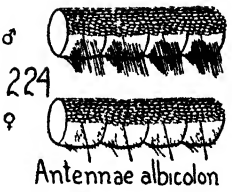
HADENINÆ


P cinctum
198
Head cinctum 195
197
Palpi cinctum
X hiemalis
202
Head hiemalis 199
♀ ♂
201
Palpi-hiemalis
Head ursina 203
205
Palpi ursina
E ursina
206
Head phoca 207
♂
a
200
♂
208
L phoca
♀ a
♂
208
♀
Antennae-phoca
210
♀
a
a Antennae-hiemalis
♂
200a
209
Palpi-phoca

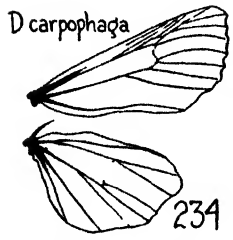

b
204
♀
b
♂
b 204
♀
b
b Antennae-ursina
Head similis 211
Head-irrisor 215
Head-mornata 219
♀
220 Antenna mornata
E similis
214
C irrisor
218
T mornata
222
B albicolon
226
213
Palpi-similis
♂ ♀
217
Palpi irrisor
♂
216
♀
Antennae irrisor
♂
212
Antenna-similis
225
Palpi-albicolon
221
Palpi-mornata

HADENINÆ

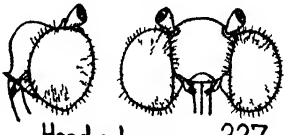

S submarina
230


♂
224
♀
Antennae albicolon

Head-albicolon 223

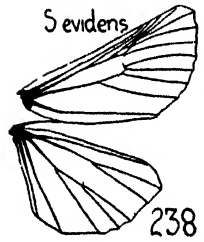

D carpophaga
234

229
Palpi submarina

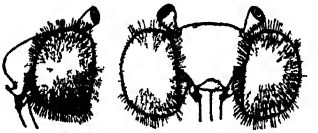

Head submarina 227

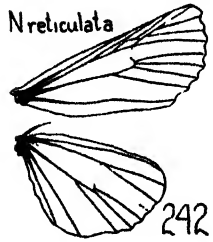
241

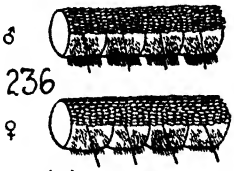
Head-carpophaga 231

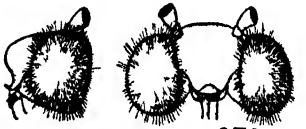

S evidens
238

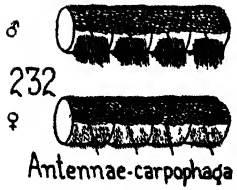
Palpi-
reticulata

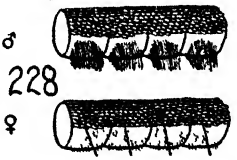

Head reticulata 239

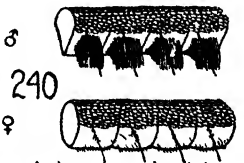

N reticulata
242


♂
236
♀
Antennae-evidens

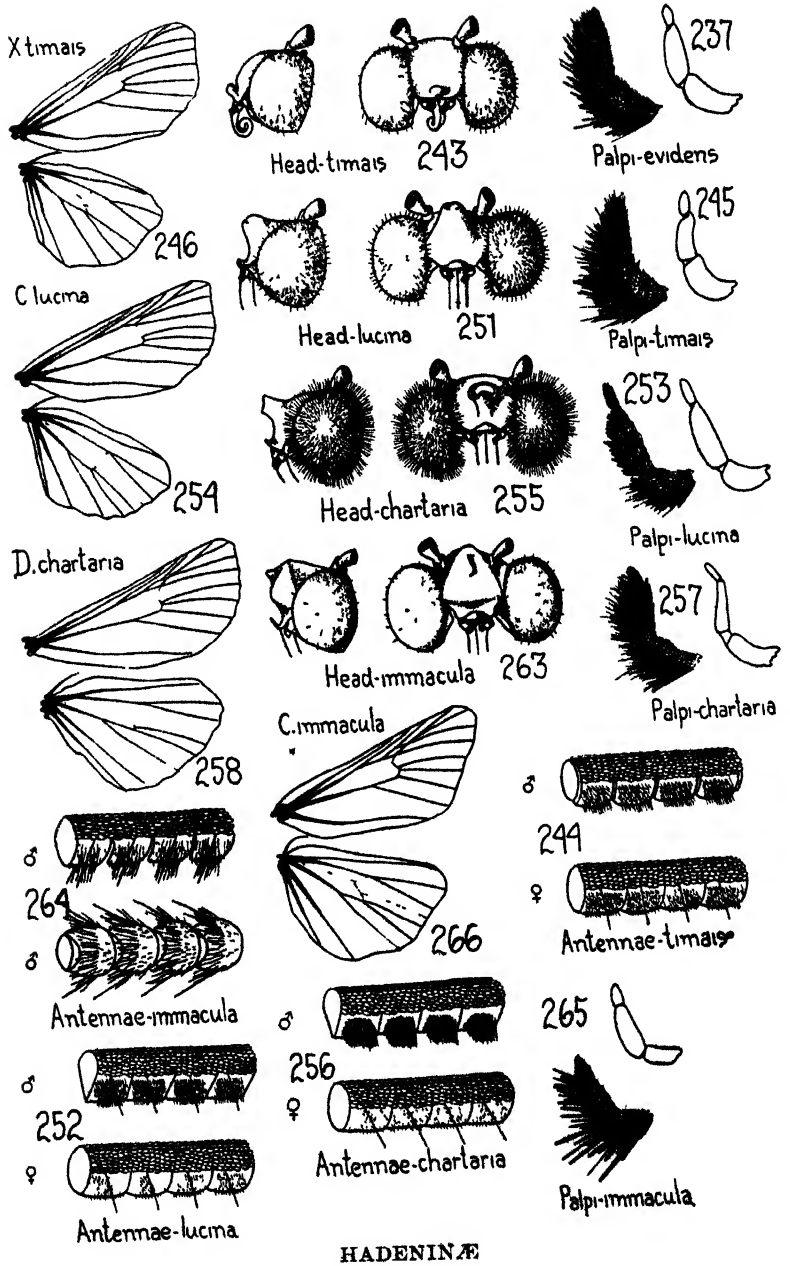

Head-evidens 235

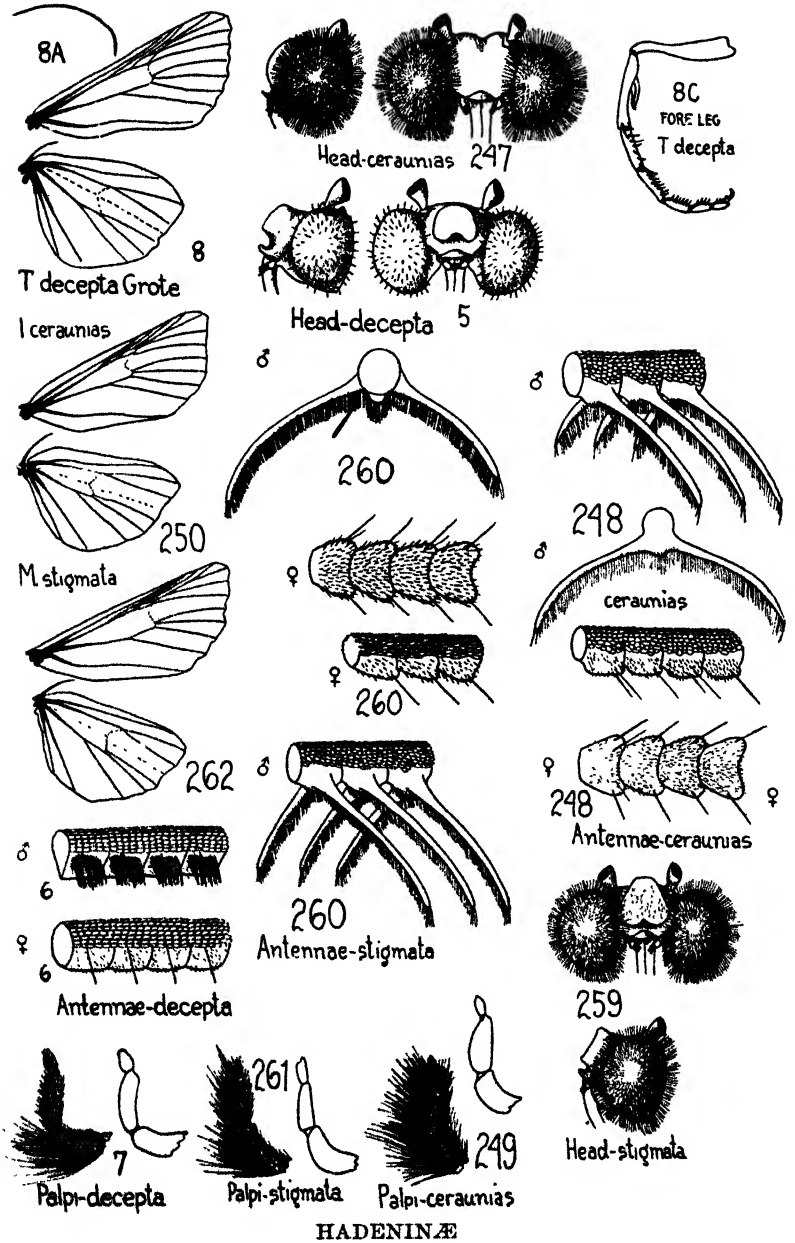

♂
232
♀
Antennae-carpophaga


♂
228
♀
Antennae-submarina

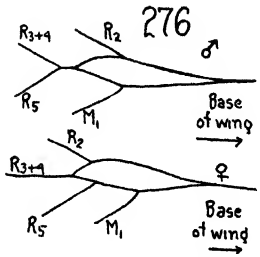

♂
240
♀
Antennae reticulata

233
Palpi-carpophaga

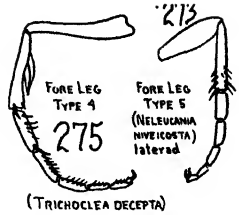

X.timais
246
Head-timais 243
237
Palpi-evidens
C.lucina
254
Head-lucina 251
245
Palpi-timais
Head-chartaria 255
253
Palpi-lucina
D.chartaria
258
Head-immacula 263
257
Palpi-chartaria
C.immacula
266
♂
264
♂
Antennae-immacula
♂
244
♀
Antennae-timais
♂
256
♀
Antennae-chartaria
265
Palpi-immacula
♂
252
♀
Antennae-lucina

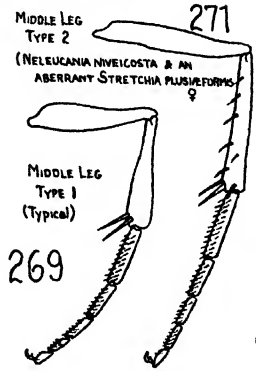

8A
8
T decepta Grote
Head-ceraunias 247
8C
FORE LEG
T decepta
Head-decepta 5
I ceraunias
250
M stigmata
♂
260
♂
♀
260
♂
248
ceraunias
262
♂
6
♀
6
Antennae-decepta
♂
260
Antennae-stigmata
♀
248
♀
Antennae-ceraunias
259
Head-stigmata
7
Palpi-decepta
261
Palpi-stigmata
249
Palpi-ceraunias

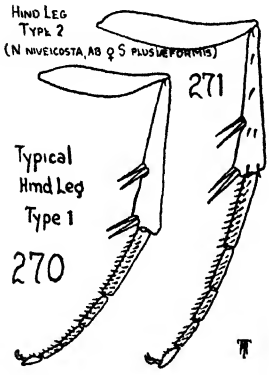
HADENINÆ

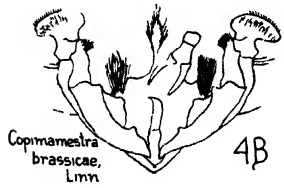


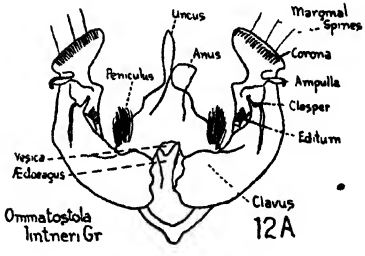
Variations in the areole of Trichoclea decepta

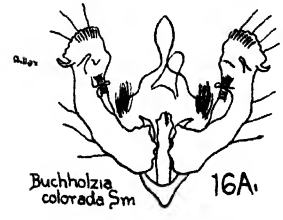


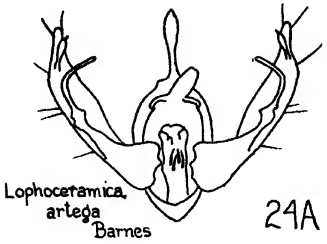






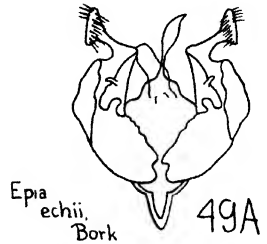


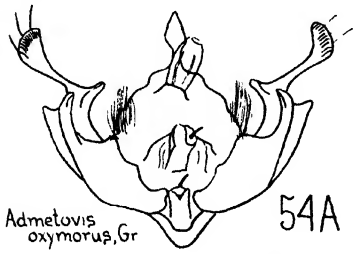



Lophoceramica artega Barnes
24A

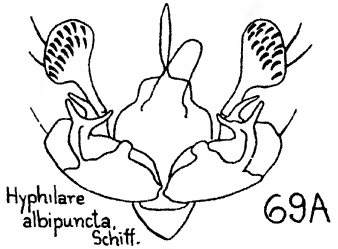
Trichopolia dentatella, Gr
32A

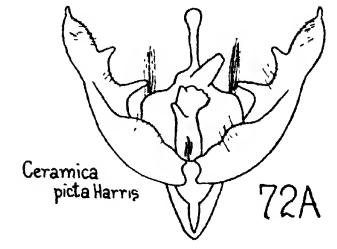
Tricholita semiaperta, Morr.
28A

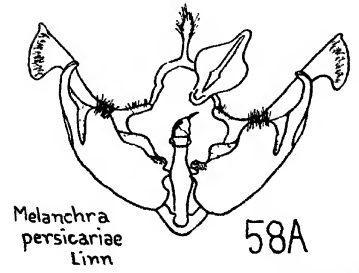

Epia echii, Bork
49A

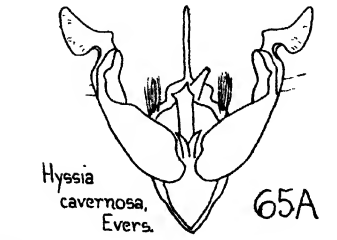

Admetovis oxymorus, Gr
54A

Ulolonche niveiguttata, Gr.
84A

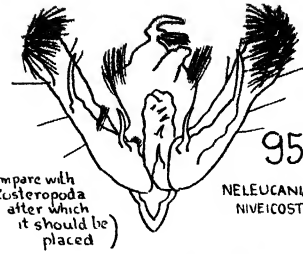

Hyphilare albipuncta, Schiff.
69A


Ceramica picta Harris
72A

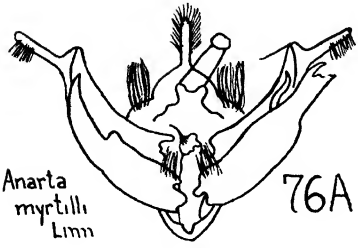

Melanchra persicariae Linn
58A


Hyssia cavernosa, Evers.
65A

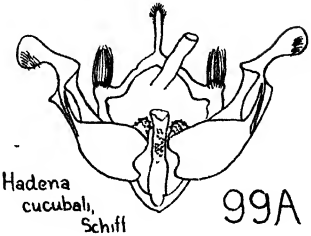
Zosteropoda hirtipes Gr 91A



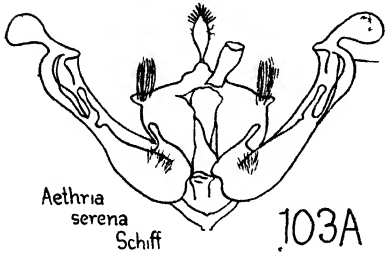
(compare with Zosteropoda after which it should be placed) 95A NELEUCANIA NIVEICOSTA SM



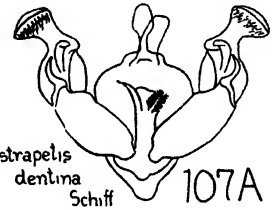
Anarta myrtilli Linn 76A



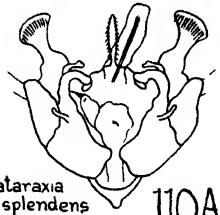
Hadena cucubali, Schiff 99A



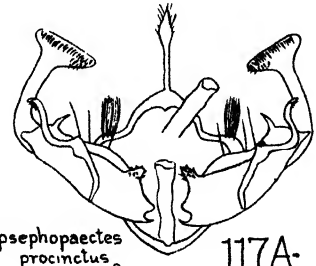
Aethria serena Schiff 103A



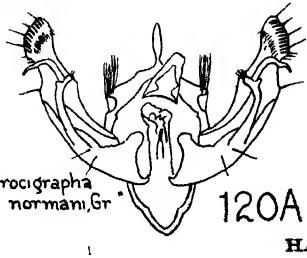
Astrapelis dentina Schiff 107A



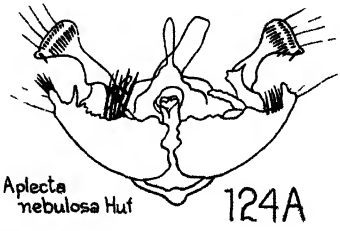
Diataraxia splendens Hub 110A



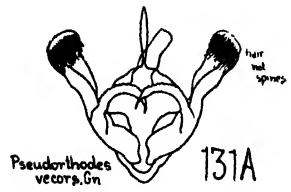
Eupsephopaectes procinctus Gr 117A

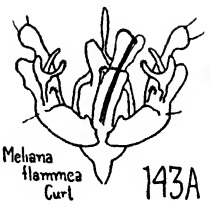


Crocigrapha normani Gr 120A

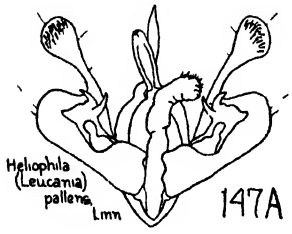


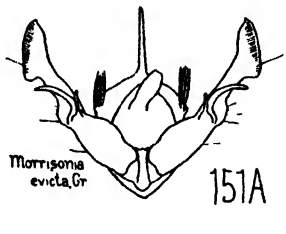
Aplecta nebulosa Hut 124A

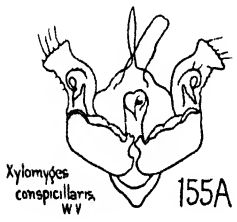

hair
wal
spines
Pseudorthodes
vecors, Gn
131A

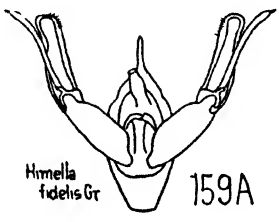

Meliana
flammea
Curt
143A

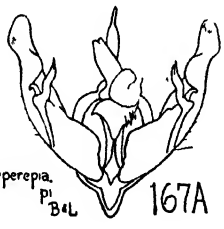
Alysia specifica Gn
163A

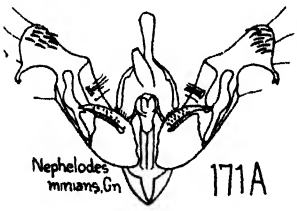

Heliophila
(Leucania)
pallens
Lmn
147A


Morrisonia
evicta, Gr
151A


Xylomyges
conspicillaris
W V
155A


Himella
fidelis Gr
159A


Hyperepia
Pl
B&L
167A

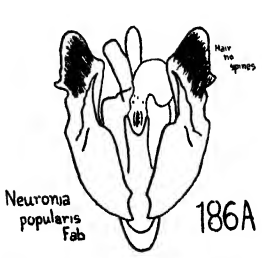

Nephelodes
minians, Gn
171A

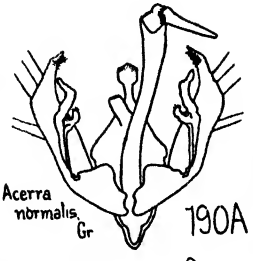
Monostola
asiatica Alp
175A

Haderonia
subarschanica,
Staud
182A

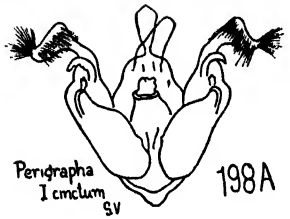
Charaeas
cespitis
W V
179A

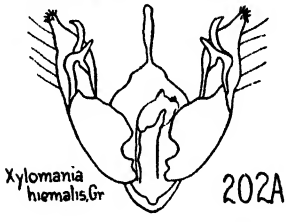
HADENINÆ

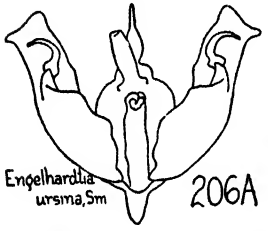

Neuronia
popularis
Fab
186A


Acerra
normalis
Gr
190A

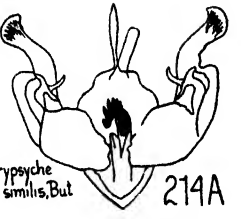
Stretchia
plusiaeformis
H Edw
194A


Perigrapha
I cinctum
SV
198A

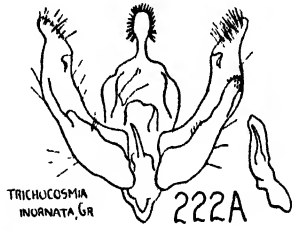

Xylomania
hiemalis,Gr
202A.

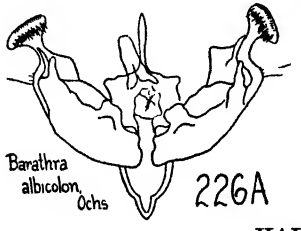

Engelhardtia
ursina,Sm
206A

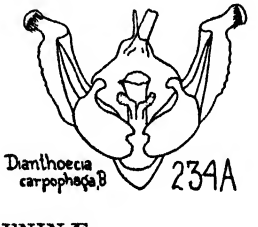
Lasiestra
phoca,
Mosch
210A


Eurypsyche
similis,But
214A

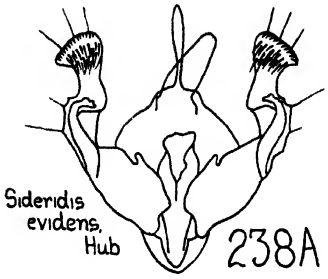
Cardepia
irrisor,
Ersch
218A


TRICHOCOSMIA
INORNATA,GR
222A

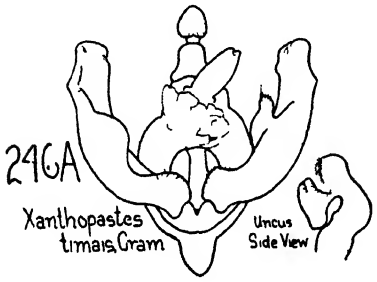

Barathra
albicolon,
Ochs
226A

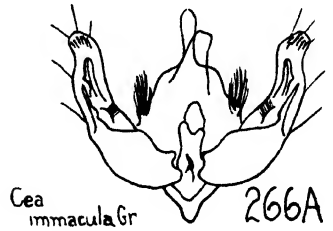

Dianthoecia
carpophaga,B
234A

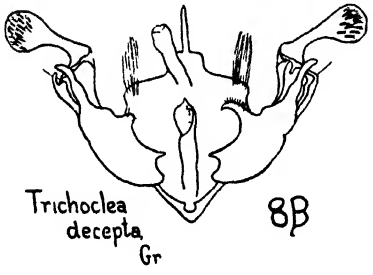
HADENINÆ

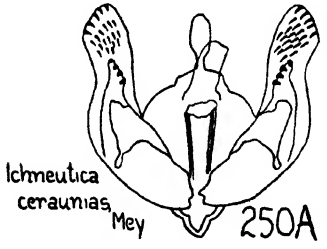

Sideridis
evidens,
Hub
238A

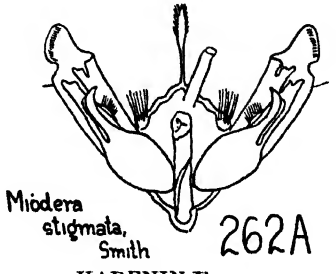
242A
Neuria
reticulata,
Vill.


246A
Xanthopastes
timais, Cram
Uncus
Side View


Cea
immacula Gr
266A


Trichoclea
decepta,
Gr
8B


Ichneutica
ceraunias,
Mey
250A


Miodera
stigmata,
Smith
262A

HADENINÆ

A SECOND RECORD OF THE DRAGONFLY NEUROCORDULIA VIRGINIENSIS

BY WILLIAM T. DAVIS, STATEN ISLAND, N. Y.

On June 21, 1919, a single female *Neurocordulia* of unknown species was collected close to the James River in Buckingham County, Virginia. No additional specimens were found though the locality was visited in subsequent years, so the insect was finally described in the "Bulletin of the Brooklyn Entomological Society," Vol. 22, June, 1927, under the name of *Neurocordulia virginiensis* Davis. Later it was again figured and compared with the type of *Neurocordulia clara* Muttkowski, in the JOURNAL, NEW YORK ENTOMOLOGICAL SOCIETY, Vol. 37, December, 1929.

On July 23, 1934, Mr. A. Earl Pritchard sent me a female *Neurocordulia* from his collection which he had correctly identified as *virginensis* and which was compared with the type from Virginia before its return to Mr. Pritchard. He has lately given me the data connected with the specimen and writes as follows: "The single female *virginensis* was taken near Broken Bow, Oklahoma, in the southeastern corner of the state, June 17, 1934, by John Standeavish. The specimen was at some rapids at a wide part of Mountain Fork River, at dusk, in company with *Platycordulia xanthosoma* Williamson. The flight of the crepuscular dragonflies is so irregular together with the dim light that selective collecting is impossible."

This is but the second specimen of this evidently rare dragonfly to be recorded in about seventeen years.

THE CRIMINAL PROSECUTION OF INSECTS

BY HARRY B. WEISS

In the November, 1926, issue of Entomological News, I wrote a little article entitled "Insects as Litigants." During the meantime, I came into the possession of a copy of "The Criminal Prosecution and Capital Punishment of Animals," by E. P. Evans, whose book is an expansion of two essays that appeared in "The Atlantic Monthly" for August and September, 1884. As insects are among the animals mentioned by Mr. Evans, and as entomologists, for the most part, are unfamiliar with this phase of historical entomology, it is believed that the present summary of Mr. Evans' account, insofar as it relates to insects, will be of interest. Mr. Evans' book was published in London in 1906 and has been out of print for many years.

Students of the history of jurisprudence have long been familiar with the early capital punishments imposed upon pigs, cows, horses and other domestic animals by secular courts, as a penalty for homicide, and with the judicial proceedings instituted by ecclesiastical courts against rats, mice and insects in order to prevent their ravages to crops, and to expel them from orchards and fields by exorcism and excommunication. Domestic animals could be arrested, tried, convicted and executed just like man, but as this was not possible in the case of insects, which were not subject to control by the civil authorities, or in fact by any human agency, the Church had to take them in hand and exercise its supernatural functions against them. This it did by resorting to "metaphysical aid." And so noxious insects were expelled or exterminated by sacerdotal conjuring and cursing. Nowadays it is customary to obtain large appropriations from Congress for this purpose. It was customary to bring some of the injurious insects to court and to put them to death while the malediction was being pronounced.

In explaining the reasons for the visitations of insect pests the Church sometimes said that they were sent by Satan, and at other times by God for the punishment of man's sins. In either case, relief was to be had only through the action of the Church.

The Council of Worms in 864 decreed that bees that had been responsible for stinging a man to death should be suffocated in their hive so that the honey would not be demoniacally tainted and unfit for food. The pastoral staff of St. Magnus was frequently carried in solemn processions, from 1685 to 1770, to such places as Lucerne, Zug and other places in Switzerland for the purpose of expelling and exterminating insects as well as rats and mice. And excommunications against insects could be purchased from Rome. At times the insects received advance warnings. Public processions were held in parishes and noxious insects were warned to stop their ravages under penalty of excommunication. Sometimes they were given a specified time, such as six days, in which to disappear.

In 1545, legal proceedings were started by the wine-growers of St. Julien against the weevil "*Rychites auratus,*" which was injuring their vineyards, but instead of passing sentence upon the insects, the official issued a proclamation recommending public prayers. It was characteristic of such proclamations to carry a preamble like the following: "Inasmuch as God, the supreme author of all that exists, hath ordained that the earth should bring forth fruits and herbs (*animas vegetativas*), not solely for the sustenance of rational human beings, but likewise for the preservation and support of insects, which fly about on the surface of the soil, therefore it would be unbecoming to proceed with rashness and precipitance against the animals now actually accused and indicated; on the contrary, it would be more fitting for us to have recourse to the mercy of heaven and to implore pardon for our sins." This preamble was followed by instructions for conducting public prayers and in this particular case, the curate attested that the instructions were fully carried out and that the insects disappeared soon afterwards.

However thirty years later there was another outbreak of the species in question and the weevils were brought to trial. The documents recording the proceedings are preserved in the archives of St. Julien and they have been printed in the "Mémoires de la Société Royale Académique de Savoie." On April 13, 1587, the case was brought before "his most reverend lordship, the prince-bishop of Maurienne, or the reverend lord his vicar-general and

official," by the magistrates and proctors, François Amenet and Petremand Bertrand, who presented the following petition for the inhabitants of St. Julien :—"Formerly by virtue of divine services and earnest supplications the scourge and inordinate fury of the aforesaid animals did cease; now they have resumed their depredations and are doing incalculable injury. If the sins of men are the cause of this evil, it behoveth the representatives of Christ on earth to prescribe such measures as may be appropriate to appease the divine wrath. Wherefore we the afore-mentioned syndics, François Amenet and Petremand Bertrand, do appear anew (*ex integro*) and beseech the official, first to appoint another procurator and advocate for the insects in place of the deceased Pierre Falcon and Claude Morel, and secondly, to visit the grounds and observe the damage, and then to proceed with the excommunication." As a result of this request Antoine Filliol was appointed procurator for the insects and Pierre Rembaud the advocate for the insects. On May 30, both parties appeared before the official and the case was adjourned to June 6, when Mr. Rembaud answered the plaintiffs by presenting a statement showing that their action was not maintainable and that they should be nonsuited. He argued that his clients, were within their right, that they had not made themselves liable to excommunication since the lower animals were created before man and that it was the intention of the Creator to assure them suitable and sufficient means of support. After more in a similar vein, and after he said that it was absurd to invoke the authority of civil and canonical law against beasts that were subject only to natural law and their instinct, he asked that the complaint be dismissed.

The case was adjourned to June 12 and again to June 19, when Mr. Bertrand the prosecuting attorney presented a long reply of which the defendants' advocate demanded a copy for study. Another adjournment took place until June 26 and as this was a holiday, no business could be transacted until June 27, when the prosecuting attorney argued that although animals were created before man, they were intended to be subordinate to him and subject to his use. The lawyer for the insects made no reply to this, but merely said that he had not yet received the document ordered on June 19, and so the case was postponed until July 4.

Antoine Filliol at that time replied to the plaintiffs and said that his opposing counsel had not even attempted to disprove the contention that lower animals were subject only to natural law. Both parties appeared before the official of St. Jean-de-Maurienne on July 18. The procurator of the insects asked for the case to be closed and the plaintiffs debarred from introducing more irrelevant matter. The prosecuting lawyer asked for a new term which was granted. Meanwhile, because of the legal delays an attempt was made to adjust the trouble by compromise. On June 29, 1587, a public meeting was called for the purpose of considering the propriety of providing a feeding place for the insects, outside of the vineyards of St. Julien. A plot of ground was selected, the inhabitants reserving for themselves the right to pass through it and to make use of the spring water on it, also the right to work the ochre and other mineral-color mines on the plot, and to take refuge there in time of war. The assemblage voted for this and a conveyance was drawn up and properly witnessed and sealed. On July 24, the proceedings of the public meeting were submitted to the court by Mr. Bertrand, procurator for the plaintiffs, who remarked upon the generosity of the commune and prayed that the grant be accepted and the insects be ordered to vacate the vineyards and be forbidden to return on pain of excommunication. The procurator for the insects asked for a copy of the process-verbal and time for consideration. This was granted and the case was adjourned until "the first juridical day after the harvest vacation" which happened to be August 11, but again by the consent of both parties, it was postponed until August 20. At this time the movement of troops through the country interfered with the trial and it was postponed to August 27 and again to September 3, when Mr. Filliol stated that he could not accept the offer made by the plaintiffs because the plot of land was sterile and not fit for his insect clients to live upon. He moved for a dismissal of the action with costs to the complainants. Mr. Bertrand denied the correctness of Mr. Filliol's remarks and claimed that the land was admirably adapted for the insects, being full of trees and shrubs. He also insisted upon a settlement in his favor.

Thereupon the official took the briefs of both parties and reserved his decision. He then appointed experts to examine the

plot of ground and to submit a written report upon its fitness to support the insects.

After so much deliberation, it is too bad that the final decision is doubtful to us because the last page of the record was destroyed by rats or insects. Various items of expense were incurred during the trial, such as fees for clerical and legal services, and for the experts. It is of interest to note that during the trial, which was conducted with all seriousness, there was no question by either side of the right of the insects to an adequate type of support suited to their nature. Nowadays it is not believed that such a right would be recognized at all with respect to insects. In addition, during the progress of the trial, no one, apparently, had any doubts about the power of the Church, by virtue of its commands, to compel the insects to stop their ravages or to move to another place. Without such a belief in the Church, the whole trial would have lacked dignity and seriousness. In insect prosecutions the lawyers for the defense always made a strong point in declaring that the insects were sent to punish people for their sins and any attempt to destroy the agents of God would be displeasing to the Almighty. Under such circumstances, the best procedure was to repent and to pray to God to remove the instrument of punishment.

As a matter of fact, insects were not really excommunicated but more properly anathematized. Insects were not taxable members of the community, and excommunication implies the exclusion from the communion of the church and from other advantages related thereto. It is one of the results of an anathema, but it is limited to members of a religious body to which insects do not belong. Anathematization was also justified on the ground that the lower animals, including insects, being emissaries of Satan, it was right and proper for them to be cursed. Some early authorities believed that the anathema should not be pronounced against the animals as such, but inferentially against the devil who made use of such animals. However, not all animals were looked upon as bad, and in "The Book of King Mode and Queen Reason," printed in 1486, animals were divided into two groups, "sweet beasts" and "stenchy beasts." Near the end of the ninth century the country around Rome was visited by a plague of "locusts" and although millions were destroyed by the peasants,

more millions remained. Eventually Pope Stephen VI, prepared large volumes of holy water with which the whole country was sprinkled, whereupon the insects disappeared. The formula used in consecrating the water implied the diabolical character of the insects against which it was directed.

Various early accounts record the effectiveness of anathemas and bans against insects by the Church. For example, during the latter half of the fifteenth century, a plague of "locusts" threatened the province of Mantua in northern Italy. The insects were dispersed by excommunication. In 1338 "locusts" started to wreck the agricultural scenery around Botzen in the Tyrol. Proceedings were therefore started against them before the ecclesiastical court at Kaltern, ten miles south of Botzen, and the parish priest proceeded against them in a solemn ceremony of anathematization. Because of the sins of the people and their delinquency in the payment of tithes, the insects, for a time, resisted the power of the church, but finally disappeared.

There was a regular order to be followed for actions against insects, involving pleas, replications, rejoinders and decisions. On both sides the pleadings were saturated with Latin quotations, classical allusions and erudition. The pleas were patchworks of rhetoric, legal lore and literary affectation.

In 1478 a species of Bruchus destructive to crops was prosecuted and anathematized in Switzerland, the trial being conducted before the Bishop of Lausanne. First a parish priest delivered a long admonition from a Bernese pulpit relative to the injury done by the beetle or "inger," as it was called, and of the suffering it caused, then the mayor and common council were approached and asked to devise ways for relief. They held a conference with the Bishop of Lausanne, who issued a mandate enjoining the insect from committing further depredations. In this mandate, the bishop urged the people to pray and then he commanded the insects, of which he said there were none in Noah's ark at the time of the deluge, to depart within six days, from the fields where they were doing their damage. If for some reason they did not see fit to depart, they were supposed to appear on the sixth day after the issuance of the order, at Wifflisburg, there to justify themselves through their advocate before His Grace the Bishop of Lausanne.

There is no further record of what happened in this particular case. No doubt it was postponed on account of a technicality, as this was a common occurrence. However, a continuation of this case or a new one happened in May 1479 with the same insect. At that time the mayor and common council of Berne sent copies of the monitorium issued by the Bishop of Lausanne to their representative for distribution to the priests of the afflicted parishes so that it might be made known from their pulpits. About a week later, on May 15, the same authorities asked the Bishop of Lausanne for new instructions and urged immediate action. Apparently the insects were doing more damage and an anathema was needed at once.

After the appointed time had expired, with the insects ignoring everyone and everything, the mayor and common council of Berne issued a document giving Mr. Thüring Fricker the power of attorney to prosecute the case. This was on May 22, 1479. The trial began a few days later and ended on May 29. In this particular case, the usual legal delays, were somehow avoided. The sentence of the court which banned and exorcised the insects, was received with great joy by the people, but nothing came of it because of the sins of the people, and God permitted the "inger" to remain as a punishment until the people repented of their wickedness and gave evidence of their love to him by giving, to the Church, tithes of what the "inger" had not destroyed.

In the malediction issued by the priest, the "inger" was characterized as a species not in Noah's ark, so that there would be no impropriety in having the Church of God curse it. It would not have been proper to curse creatures that God had made and pronounced good and which he had taken pains to preserve from destruction by the deluge.

On June 26, 1659, Capt. J. B. Pestalozzi, appeared before commissioner Hartmann Planta, on behalf of the communes of Chiavenna, Mese, Gordona, Prada, and Samolico, and made a complaint about certain caterpillars, demanding that they should be summoned to appear in court in order to have a curator and defender appointed for them, to answer to the plaintiffs. This was done, a summons was issued, copies were posted in the forests and the advocate of the insects was ordered to appear in court on

behalf of his clients which were charged with trespassing upon fields, gardens and orchards where they did great damage, instead of remaining in the forests where they belonged. A trial was held and a definite place of abode was to be assigned to them. Here the record ends. The court recognized the right of the caterpillars to life, liberty and the pursuit of happiness, provided the exercise of such a right did not infringe upon the happiness of man "to whom the lower animals are subject." Other extant records involving such ecclesiastical acts as have been noted, refer to termites, gadflies, and other insects. Peasant communities were always willing to ward off insect devastations at the expense of their neighbors. In some cases the insects were notified verbally that better entertainment was to be had at another village.

In closing, a weak survival of ecclesiastical excommunication, that existed in these United States in 1888, may be noted. Mr. W. W. Newell in "The Journal of American Folk-Lore" (Jan.–Mar., 1892), records a letter that was written to rats in order to induce them to quit certain premises. This letter was rubbed with grease and stuffed into the runs of the rats so that it would not be overlooked. This particular letter was dated, "Maine, Oct. 31, 1888" and addressed to "Messrs. Rats and Co." The author began by expressing deep interest in the welfare of the rats, as well as concern lest they find their winter quarters in No. 1, Seaview Street, uncomfortable and with little food, since it was only a summer residence. He suggested that they move to No. 6 Incubator Street where they would be much happier. Here they could live in a cellar well stocked with vegetables and they would also have easy access to a barn containing grain. The writer concluded by advising the rats that no harm would come to them if they took his advice. But if they didn't he would use "Rough on Rats" against them.

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF MAY 5, 1936

A regular meeting of the Society was held on May 5, 1936, in the American Museum of Natural History; President Ruckes in the chair with thirty-five members and forty-six visitors present.

Dr. Klots announced that the next meeting would be given over to a discussion of notes by members and summer collecting plans.

Upon the suggestion that there be a field trip, Dr. Ruckes appointed a committee composed of Messrs. Nicolay and Richard and Miss Clausen to draw up plans for field meetings.

Mr. W. U. Doyle of 176 Undercliff Ave., Edgewater, New Jersey, was duly proposed and elected to membership.

Mr. Proctor plans to spend the summer at Mt. Desert Island. To members of the Society, in the neighborhood during the summer, he very kindly offered to show them around. Members expecting to visit him, however, must let him know in advance.

Mr. Davis, the speaker of the evening was then introduced. The New York Entomological Club, said Mr. Davis, started as Sunday afternoon talks held at the homes of the various members. The Club was founded October 3, 1880, and incorporated in 1893. Mr. Davis read several minutes of the earliest meetings. It was interesting to note that even as early as 1880 there existed serious financial difficulties.

The founders had the unique idea of selecting famous biologists and entomologists as honorary corresponding members. Included in this list were such men as Darwin and Lubbock. The earliest publication was called "Papilio," dedicated to the Lepidoptera, with the idea of eventually adding other topics. A committee was also appointed on nomenclature, the object being to settle doubtful points in connection with synonomy and to arrive at decisions concerning entomological species. Out of the failure of "Papilio," "Entomologica Americana" issued forth.

Mr. Grote, the second oldest member of the Society, said that the club started when New Yorkers rebelled at the idea of going to Brooklyn for meetings. He was president in 1902 and 1903 after having been treasurer for several previous years. Dr. Ditmars, by his permission, was allowed to read his first public paper on the "Snakes of Central Park." Mr. Grote closed his remarks by thanking the Society for being allowed to speak and for being made a life member.

Mr. Bird spoke of the contributions made by the Society and by Mr. Davis to the Society. He instructed Mr. Davis to carry the good wishes of the Society to Mr. Leng.

Mr. Davis regretted very much that the evening was so short that he could not go into more detail. Even though he had to deal with his subject in a superficial way the members found the meeting a most enjoyable one.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF MAY 19, 1936

A regular meeting of the Society was held on May 19, 1936, in the American Museum of Natural History; President Ruckes presiding with nineteen members and eleven visitors present.

The Field Committee reported on plans for a field trip every three weeks during the summer. The schedule of trips was as follows:

May 31	(Sun.)	West Nyack, N. Y.
June 14	(Sun.)	Greenwood Lake, N. J.
July 12	(Sun.)	Lakehurst, N. J.
Aug. 15–16	(Sat.–Sun.)	De Bruce, N. Y.
Sept. 20	(Sun.)	Bear Mt., N. Y.

Dr. Lutz and Dr. Gertsch were ahead of anyone in their spring collecting, having started in on February 5 in Panama. They collected about 17,000 specimens, chiefly Lepidoptera. Dr. Lutz plans to probably continue life history work at Ramsey and also to record the sound of insects. Dr. Gertsch told of the abundance of chiggers or red bugs at Barro Colorado Island. Ticks were also very common.

Doctors Melander and Klots gave a short résumé of some collecting done early this year.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF OCTOBER 6, 1936

A regular meeting of the Society was held on October 6, 1936, in the Roosevelt Memorial; President Ruckes in the chair with twenty-eight members and twenty-four visitors present.

Dr. Ruckes welcomed the Society to its new quarters in the Roosevelt Memorial.

The Field Committee reported that at the Society's first trip of the year twenty members were present. The members were the guests of Mr. Richard. Inclement weather made it impossible for the other scheduled trips to be held.

Dr. Tindale, of the South Australian Museum, was scheduled to speak at the next meeting on "Notes on Insect Collecting in Australia."

Dr. Melander proposed Dr. H. Hagen and Dr. V. Argo, both of the C. C. N. Y. faculty, for membership. Dr. Curran moved that the rules be suspended in order to elect them at once.

Mr. Kisliuk called the attention of the Society to the death of J. W. Folsom.

The speaker of the evening, Dr. Gibson, Dominion Entomologist, was then presented. The Bureau of Entomology in Canada, said Dr. Gibson maintains twenty research laboratories, five or ten temporary field laboratories and ten plant inspection sites. Dr. Gibson explained that insects recognize no

boundary line between Canada and United States. Consequently there is a mutual trading of insect pests beyond the control of either country.

Grasshoppers from U. S. have become so well established 100 miles north of the boundary that effective control measures have to be taken. On the basis of per cent of eggs per area, maps may be made. From these maps the amount of poison necessary to kill the insects the following spring may then be calculated.

Biological control is of vital interest to the Bureau. All of the parasites used are of European origin collected in Hungary and other countries especially for breeding purposes. There are several notable successes in establishing parasites. *Macrocentrus*, a parasite of the peach moth, has become so well established that the peach moth is now seldom found.

The Satin Moth which defoliates trees caused very serious trouble. *Apanteles* were obtained, bred, and released. This parasite had by 1935 caused infestation of the Satin Moth to completely disappear.

In the Gaspé Peninsula the European sawfly was fast destroying spruce. The parasite *Microplectron* was reared and in 1936, 12,321,426 specimens were liberated. These liberations were usually made in units of 10,000.

Dr. Gibson closed his remarks with a detailed description of the new parasitology laboratory at Bellville. It is the best in the world with all accommodations for complete control of conditions at all times of the year.

At the close of Dr. Gibson's talk there was a general discussion by members.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF OCTOBER 20, 1936

A regular meeting of the Society was held on October 20, 1936, in the Roosevelt Memorial; President Ruckes in the chair with twenty-seven members and fifteen visitors present.

Mr. Henry Bird proposed Professor P. A. Readio, Department of Entomology, Cornell University, Ithaca, N. Y., and Dr. Curran proposed Dr. T. L. Guyton, Sherwin Williams Co., Bound Brook, New Jersey, for membership.

Mr. Engelhardt reminded the members that the next meeting of the Brooklyn Society on November 12 would be in commemoration of the 50th anniversary of its founding.

Dr. Curran made a motion to suspend the by-laws in order to postpone the next meeting because of Election Day.

In view of the fact that there would be no meeting on November 3, Mr. Mutchler proposed suspension of by-laws in order to elect the proposed members to the Society. Acting upon this proposal Professor Readio and Dr. Guyton were elected to membership.

Dr. Ruckes then presented the speaker of the evening, Mr. N. B. Tindale, of the South Australian Museum. From Mr. Tindale the members learned that Australia is troubled by the same insect pests that bother the United States, such as the peach moth. Insects of SW. Australia however are of an archaic nature due to their habit of living in a desert forest.

What is known as Palm Valley is in the midst of sterile desert but in itself it is a gem of fertility. Certain Neuropteroid insects are found only there.

The natives, said Mr. Tindale, are very fond of sweets. In order to obtain this delicacy they take advantage of the way certain ants store honey. They dip up these ants one by one and when they have collected a handful enjoy their rare treat. Children depend largely upon insects for the fat necessary to keep them healthy. They eat from twenty to thirty grubs a day. These grubs may be either toasted or eaten raw.

In times of scarcity of food natives turn up the ground in search of grubs. They also depend upon certain ants that gather grass seed about their mounds. The natives search for these mounds and then use the grain.

Mr. Tindale brought his talk to a close by remarking upon the constancy of association of Australian fauna with that of Patagonia.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF NOVEMBER 17, 1936

A regular meeting of the Society was held on November 17, 1936; President Ruckes in the chair with twenty-four members and seventeen visitors present.

The program committee reported that Dr. Melander would address the Society at the next meeting, his topic being "Behavior of Some Insects and Their Relatives," to be illustrated with motion pictures.

Dr. Ruckes spoke of having visited the Brooklyn Entomological Society on its fiftieth anniversary.

The long-postponed session given over annually to "Notes by Members" was the program of the evening.

Mr. Angell collected at Engelwood Cliffs, N. J. He mentioned *Stratogodes septemtrionus* Csy. and *Nyas cyanescens* as being of special interest.

Mr. Comstock said he made twenty-two field trips. On these trips he collected 3,000 specimens principally in twelve orders. Collecting was very poor and most of it was done by sweeping.

Dr. Lutz spoke of the experiments he made this summer on the sound recording of insects.

Mr. Davis exhibited several interesting cicadas. The types of these species were presented to the American Museum of Natural History. They are: *Tibicen nigraoalbata, Platypedia balli* and *Tibicen curvispinosa.* Some cicadas from the southwestern part of the United States, according to Mr. Davis, are similar to those occurring in Europe. He also told of having received Peripatus (*Peripatoides novae-zealandiae*) and *Heterojapyx novae-zealandiae* and these two specimens have been given to the Staten Island Institute of Arts and Sciences.

Dr. Fox during his summer vacation studied the relative abundance of insect population. He found *Conocephalus ornata* which is usually confined to the Mississippi Basin along the Palisades.

Dr. Melander exhibited pictures taken on the first field trip of the season of the New York Entomological Society. These included both motion and still pictures. Studies of the behavior of insects as well as some of their relatives that have occupied Dr. Melander this summer will be the subject of a talk at the next meeting.

Mr. Olsen who was just back from a trip on the *Zaco* to the South Sea Islands related some of his experiences. The object of the trip was to collect material for a Museum group on pearl diving. The short time available to him for entomological purposes netted few specimens.

Mr. Harry B. Weiss spent the summer collaborating with the New York Public Library resulting in an annotated list of insects affecting books.

Caribidæ seemed to be very scarce this year according to both Mr. Proctor and Mr. Nicolay. Mr. Proctor remarked that there seemed to be fewer Carabidæ each year at Bar Harbor. Mr. Nicolay was of the same opinion concerning the scarcity of Carabidæ in Florida and in the vicinity of Washington.

Dr. Smith spent the summer traveling in Europe. He visited various museums in order to study chrysopids. Of all the museums visited he was most enthusiastic of the Live Insect Exhibit at the Berlin Zoological Gardens.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF DECEMBER 1, 1936

A regular meeting of the Society was held on December 1, 1936; President Ruckes in the chair with twenty-seven members and twenty-seven visitors present.

The program committee reported that Dr. Felt would address the Society at the next meeting on "Insect Enemies of Shade and Ornamental Trees," illustrated with lantern slides.

The following were proposed for active membership in the Society: Mr. Louis A. Tomka, 234 E. 36th Street, New York City; Mr. James H. Maier, 284 10th Ave., New York City, and Mr. Alfred Fenton, Texaco Sulphur Co., Second National Bank, Houston, Texas.

The meeting was then given over to the speaker of the evening, Dr. Melander. Discarding the collecting net Dr. Melander spent the summer in taking insects in their natural surroundings. Most of his work was done in New England. The equipment necessary consists of an abundant supply of patience, a quiet day and lots of sunshine. Displayed upon the screen the members then witnessed insects behaving and misbehaving amid their natural surroundings and in color. Everyone enthusiastically praised Dr. Melander's marvelous motion pictures of insects and some of their relatives.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF DECEMBER 15, 1936

A regular meeting of the Society was held on December 15, 1936; Dr. Ruckes in the chair with eighteen members and fifteen visitors present.

The program committee announced that Dr. A. Glenn Richards, Jr., would speak on January 5, 1937, on "Development and Evolution of Wing Patterns of Lepidoptera."

The following were elected active members of the Society: Mr. Louis Tomka, Mr. James H. Maier and Mr. Alfred Fenton.

Dr. Ruckes appointed a nominating committee composed of Mr. Bell, Mr. Sherman and Mr. Mutchler.

An invitation to members to attend the Science Meetings at Atlantic City was read by Dr. Ruckes.

The members discussed the proposed change of name of the American Association of Economic Entomologists to the American Association of Entomologists. A motion was made and seconded that the President or a representative delegate appointed by him would represent the Society in this matter at the Atlantic City meetings.

Dr. Felt, the speaker of the evening, spoke upon "Insect Enemies of Shade Trees." Dr. Felt's talk was illustrated by slides to show the effects of repeated attacks by insects as well as the characteristic damage done by these insect pests.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF JANUARY 5, 1937

An annual meeting of the Society was held on January 5, 1937; President Ruckes in the chair with twenty-five members and seventeen visitors present.

The program committee reported that Mr. Henry Bird would lead the general discussion at the next meeting with remarks on "The Remarkable Insect Fauna of the Fruit of a Native Fig."

Mr. Mutchler read the report of the nominating committee, as follows:

President: Dr. C. H. Curran
Vice-President: Dr. William Moore
Secretary: Lucy W. Clausen
Treasurer: Paul T. Richard
Librarian: Frank E. Watson
Curator: Andrew J. Mutchler
Executive Committee: William T. Davis, Frank E. Lutz, William Proctor, Herbert F. Schwarz, Henry Bird
Publication Committee: Harry B. Weiss, H. T. Spieth, John D. Sherman, Jr., E. L. Bell
Delegate to the New York Academy of Sciences: William T. Davis

Nominations were closed and the secretary was empowered to cast one ballot for the officers as nominated.

Dr. Ruckes then turned the meeting over to the new president, Dr. C. H. Curran.

The resignation of Dr. William Wiegman was accepted with regret.

Dr. Wolfgang VonHagen was proposed for active membership.

Dr. Curran appointed the following committees:

Program: Dr. A. B. Klots, Dr. A. L. Melander, Mr. M. Kisliuk

Auditing: Dr. A. L. Horsfall, Mr. Frank Johnson, Dr. Henry Fox

Field: Mr. A. S. Nicolay, Mr. H. Moennich, Mr. H. Dietrich

Dr. A. Glenn Richards, the speaker of the evening, took the floor. The topic discussed was "Development and Evolution of the Wing Pattern of Lepidoptera." The lepidopterous wing is largely a self-differentiating system independent of the rest of the body. This is proven by transplanting anlagen, by culturing anlagen *in vitro* and by delayed development of wings upon which operations have been performed.

There are two fundamental points in the determination of pattern. First, that there are "sensitive periods" during which the pattern may be modified by external agents and before and after which it is unaffected by these same agents. The different parts of the pattern have sensitive periods at different times so that it is possible to modify one pattern-component without in any way affecting the other.

Second, the pattern is irrevocably fixed by a "determination stream" which flows like a stream across the wing, determining the parts thereof. There are two types of determination streams known: one from the base outward (based on the analysis of intersexes and gynandromorphs), the other from the ventral surface over the central symmetry-field.

There is fundamental similarity between the results of comparative-morphology, developmental physiology and genetical analyses of mixed populations. This work proves that "aberrations" have no status in phylogeny, but are merely *normal* individuals which by chance have developed under not normal conditions.

Seasonal forms are viewed as generally due to diapause versus non-diapause development.

A complete review of this subject is to appear in the June issue of the JOURNAL.

A general discussion followed the talk of the evening.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF JANUARY 19, 1937

A regular meeting of the Society was held on January 19, 1937; President Curran in the chair with twenty-five members and fifteen visitors present.

The Secretary being absent Dr. Ruckes was asked to be secretary *pro tempore.*

The program committee reported that at the next meeting Dr. C. C. Hamilton would address the Society on "The Use of Autogyro and Airplane in

Insect Control.'' Dr. Hamilton is from the New Jersey State Experiment Station.

Dr. Wolfgang VonHagen was elected to active membership.

The President called attention to the untimely deaths of Professors Crosby and Tillyard. On motion duly seconded and passed Dr. Klots and Dr. Leonard were instructed to write a letter of condolence on behalf of the Society.

Mr. Comstock recalled a series of lectures of which he showed the outline that were given in the American Museum of Natural History in 1894. He also recalled the interesting memorandum of an auction of Lepidoptera conducted by Dr. Ottolengui in 1896. Mr. Davis said that the success of such auctions was due to the leadership of Mrs. Annie Trumbull Slosson and that there were few auctions because the financial condition of the Society improved rapidly and there was no need of raising money by this method.

Mr. Comstock further remarked upon the possible use of paradichlorobenzene as a therapeutic means of controlling ringworm infections.

The program of the evening was opened by Mr. Henry Bird who gave a most interesting talk on the Insect Fauna of the Native American Fig.'' The remarkably numerous insect fauna of a native fig, *Ficus populina* Willd., of southern Florida was discussed by Mr. Bird and particular attention was drawn to the presence of a *Blastophaga* species seemingly different from *B. grossorum* which was the foreign species introduced into southern California for the caprification of the Smyrna fig. The growing of this variety of the fig in favorable regions of the southwest was equally dependent on this minute wasp to carry pollen from another form bearing staminate flowers, the same as happen in Asia Minor. Its introduction and the working out of its complicated biology was pointed out as a classic of entomology along with that of the *Pronuba* moth and the cross-pollination by the latter of the Yucca plant.

If in the discovery of this Floridian *Blastophaga* it proves that we are dealing with a native species, it might have been of equal assistance to the Californian fig growers, as the imported one. These female wasps are concerned with placing their eggs in the flower of some other fig than that from which they emerged and any in proper condition seem to do so, as long as they are near at hand. Only males without wings and curious creatures, were encountered. These formed but a small fraction of the hundreds of examples emerging from *F. populina* fruit wherein occurred seven other species of Chalcidoidea, and a new gall midge of the genus *Ficiomyia*.

Mr. George Rau gave an excellent summary of the scale insects found in the greenhouses at Bronx Park. His remarks were illustrated by a large collection of living scales which he showed. In 1921 Dr. Morrison found thirty-nine species of scale insects in the greenhouses of the New York Botanical Gardens. During the course of Mr. Rau's collecting he has found twenty-two new records in the same greenhouses, eight of which have been previously recorded by others from different greenhouses in the state. The following are recorded for the first time from the U. S.:

Asterolecanium aureum Bdv.
Chrysomphalus umbonatus Newst.
Kuwanaspis hikosani Kw.
Lecanium decemplex Newst.

In a preliminary survey of the same greenhouses the following parasites of scale insects were found:

Aphytis diaspidea How. on *Diaspis zamiae* Morg.
Aphytis chrysomphali Mercet on *Chrysomphalus umbonatus* Newst.
Aspidiotiphagous citrinus Craw. on *Kuwanaspis hikosani* Kuw.
Coccophagus immaculatus How. on *Ericoccus azaleae* Comst.
Coccophagus lycimnia Walker (*C. lecanii* Fitch) on *Coccus hesperidum* L.
Encyrtus infelix Embleton on *Saissetia hemisphaerica* Targ.
Leptomastidea abnormis Gir. on *Pseudococcus citri* Risso

In addition the thrips *Aleurodothrips fasciapennis* Franklin is predacious upon *Saissetia hemiphaerica* Targ. and *Watsoniella elongata* Watson is commonly found attacking *Odonaspis secreta* Ckll.

Undoubtedly the most serious insect pests of greenhouse plants are the mealy bugs of which six species require control measures.

The Mexican mealybug *Phenacoccus gossypii* is considered by many entomologists the most serious insect found in greenhouses. This insect has gained entrance into a number of greenhouses within the last ten years and may do great damage to Chrysanthemums and other plants.

Rhizoecus falcifer Kunck. attacks the roots of palms. The cottony masses of this insect are mistaken for a fungus growth.

The greenhouse whitefly *Trialeurodes vaporariorum* Westw. is heavily parasitized by *Encarsia formosa* Gahan and the entomogenous *Aegerita webberi* Fawcett.

LUCY W. CLAUSEN, *Secretary.*

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SEVEN NEW SPECIES OF ASIATIC TIPHIA

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INTRODUCTION

In the course of the scouting and experimental work carried on at the Yokohama Laboratory of the Division of Japanese and Asiatic Beetle Investigations during 1931 and 1932 a collection of specimens of *Tiphia* was accumulated which, subsequent studies revealed, involve several new species. The guide used during the study of this collection was the publication "Contribution to the Taxonomy of Asiatic Wasps of the Genus Tiphia (Scoliidæ) by Allen and Jaynes."[2] Although it was obvious that some of the specimens were closely related to species represented in Allen and Jaynes' key, the lack of sufficient material for comparative purposes made it necessary for the author to postpone more conclusive studies until his return to the United States. With the aid of the collection of Asiatic *Tiphia* at the

[1] The author sincerely appreciates the cooperation of H. W. Allen, whose helpful advice and criticism were so willingly given. Thanks are also due to K. Sato for his assistance in originally segregating the new species in the Yokohama Laboratory collection.

[2] Contribution to the Taxonomy of Asiatic Wasps of the Genus Tiphia (Scoliidæ). H. W. Allen and H. A. Jaynes. No. 2814.—From Proceedings of the United States National Museum, Vol. 76, Art. 17, pp. 1–105, illus. 1930.

laboratory at Moorestown, N. J., this work was finally completed and the seven new species presented in this paper were described.

No rearing work was conducted with the species *corpulenta* and *mediocris* but the males used in the descriptive work were collected under circumstances which leave little doubt as to the authenticity of their relationship to the female types. The description appearing herein are, for the most part, given in the descriptive style and phraseology employed by Allen and Jaynes, changes being made only where new diagnostic characters are involved.

GROUPING OF THE NEW SPECIES

Allen and Jaynes, in their publication previously referred to, have divided the species represented in their key into eight taxonomically related groups, each group bearing the name of the species most typically representative of it. This same system has been used in the present paper and each of the seven species herein described has been assigned to its respective group as determined by Allen and Jaynes. These authors place *Tiphia vernalis* Roh. in a position by itself although indicating a relationship to the *agilis* group. Since the species herein described as *Tiphia burrelli* runs out to *vernalis* in the aforementioned key, it is grouped with that species in this paper, although the characters of the female more closely resemble those of *popilliavora* than those of *agilis*.

The case of *Tiphia homoncularis*, n. sp., however, appears to be a departure from the grouping of species as laid down by Allen and Jaynes. In this species the female keys out to *agilis* of the *agilis* group while the male keys out to *malayana* of the *malayana* group. Apparently *homoncularis* is a species which may be considered as a connecting link between these two groups, whose representatives are, in fact, not radically different from one another, particularly as to male characters.

In the following tabulation are listed the species described in this paper together with the couplet numbers to which they run in the above-mentioned key, and the groups within which they fall.

Couplet Nos.

Name	*Female*	*Male*	*Group*
Tiphia homoncularis	24	17	agilis-malayana
Tiphia juliana	37	24	agilis
Tiphia isolata .	7	24	rufomandibulata-agilis
Tiphia corpulenta	32	19	popilliavora
Tiphia mediocris	32	19	popilliavora
Tiphia burrelli	38	15	vernalis
Tiphia castaneaevora	37	24	agilis

Each of the above-listed species runs out to the indicated couplet in the key by Allen and Jaynes, and for purposes of further identification the following key is offered.

KEY TO FEMALES

A.—With hind basitarsus grooved.
B.—Side of pronotum with a groove across center.
C.—Tegula red, transparent and thin *homoncularis*
CC.—Tegula black and opaque.
D.—Pygidium with impunctate apex wrinkled *corpulenta*
DD.—Pygidium with impunctate apex smooth.
E.—Mandibles at least with a shallow median groove. *mediocris*
EE.—Mandibles without median groove *burrelli*
BB.—Side of pronotum without a groove across center.
F.—Second intercubital vein strongly sinuous *castaneævora*
FF.—Second intercubital vein straight or nearly so *juliana*
AA.—With hind basitarsus not grooved *isolata*

KEY TO MALES

A.—Antennocular distance less than width of antennal fossa.
B.—Tegula with Tegula with groove on lateral or posteriar margin . . *burrelli*
BB.—Tegula without such a groove *homoncularis*
AA.—Antennocular distance at least as great as width of antennal fossa.
B.—Clypeal extension having an impunctate margin.
C.—Lower half of front lightly shagreened; primary punctures of clypeo-antennal region confined to a patch but little broader than base of clypeal extension *corpulenta*
CC.—Lower half of front not shagreened; primary punctures of

clypeo-antennal region extending across greater portion of this region . . . . . *mediocris*

BB.—Clypeal extension without impunctate margin.

C.—First sternite with longitudinal extension of median keel faintly discernible to posterior sulcus; median extension of clypeus truncate; sides of propodeal areola concave *isolata*

CC.—First sternite without such longitudinal extension of median keel; median extension of clypeus roundly emarginate; sides of propodeal areola nearly straight though convergent posteriorly.

D.—Punctures on anterior portion of first sternite much larger and coarser than those in preapical band of first tergite *juliana*

DD.—Punctures in anterior portion of first sternite but little larger than those in preapical band of first tergite. *castaneaevora*

Tiphia homoncularis new species

FEMALE.—Vertex with a few series of primary punctures of second-degree density extending through and behind ocellar triangle, primaries denser medially than on either side. Front very faintly shagreened, visible in strong light; groove, if present, frequently interrupted; primary punctures sparse, denser on anterior third, where they are evenly distributed between the eyes, chiefly of second-degree density, except broadly on the median upper front, where density is of third degree. Impunctate apex of clypeal extension poorly defined by an irregular row of coarse punctures, its longitudinal extension approximately one-half the distance from apex of clypeus to edge of antennal fossa. Flagellum of antenna fulvous beneath. Pronotum with primary punctures on posterior margin of punctate area deeper than other primary punctures in this area; secondary punctures sparse and widely scattered; sides of pronotum with well defined groove across center. Scutum with its notauli and its antero-medial groove continuous or nearly so. Metanotum beset with primary and secondary punctures on its periphery, with its largest discal punctures smaller than those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with a shallow groove extending about one-half the length of the joint, and a group of three lanceolate spines on the outside, one of which is apical. Tegula thin, red, polished and transparent. Wings slightly smoky. Propodeal areola almost rectangular, two and one-half to three times as long as wide; carinæ narrow and uniform, bordering grooves if present shallow and interrupted; median carina ending just before posterior transverse carina. Lower portion of sides of propodeum shagreened, with patch of microscopic appressed hairs in posterior angle. Posterior aspect of propodeum with median carina weak but complete. First abdominal tergite with single band of well defined punctures across dorsum, becoming wider and abruptly depressed laterally. First sternite with lateral grooves on

posterior half, and a few scattered punctures anteriorly. Tergites polished, impunctate margins medially about 3 to 4 times width of largest bordering punctures. Pygidium uniformly reticulato-punctate on basal half, with polished impunctate emargination; apex scarcely wrinkled and not shagreened. Length 6 to 9 mm.

MALE.—Vertex with primary punctures in and immediately behind ocellar triangle more numerous than on either side. Front at least faintly shagreened; preocellar area on upper half with primary punctures in uniform second-degree and third-degree density and with interspaces at least as broad as an ocellus; secondary punctures generally lacking though primaries gradually diminish in size toward bases of antennæ. Antennocular distance less than width of antennal fossa. Clypeal extension with its apical width at least as great as distance from apex of clypeus to edge of antennal fossa; disk flat, apex distinctly roughly emarginate, with narrow, irregularly impunctate area antero-medially. Flagellum infuscated beneath. Pronotum faintly shagreened; primary punctures largely of third-degree density; a few scattered secondary punctures antero-medially. Side of pronotum striate, with groove extending across center in broadly rounding curve for at least one-half the width of the sclerite; no punctures. Mesepisternum shagreened; primary punctures diminishing in size and density away from prepectus, everywhere of third-degree density; secondary punctures conspicuously less numerous than primaries over a vaguely defined area in center anterior to spiracle. Scutellum without impunctate apex as wide as lowest primary punctures. Metanotum variable. Tibiæ and femora partly reddish. Tegula polished, red to red-black, and transparent. Wings subhyaline, with radial cell exceeding second cubital cell in apical extension Propodeum with its transverse carina extending far forward medially; areola two to two and one-half times as long as wide, its sides slightly divergent anteriorly, the lateral carinæ bordered on the outside by shallow indistinct crenulate grooves, the median carina extending from anterior limit of areola posteriorly three-fourths to four-fifths the distance to transverse carina; lower portion of sides of propodeum finely striate, devoid of hairs or punctures; posterior aspect with lower three-fourths covered with fine hairs and minutely punctate, upper fourth polished, and generally with a few scattered, shallow, coarser punctures medially; median carina weak, rarely present on more than lower three-fourths. First tergite with narrow preapical band of well differentiated punctures in slight depression. First sternite polished, lateral grooves faint and interrupted on more than posterior half; impunctate except for occasional scattered punctures on anterior half, constricted portion with an elongate median keel. Tergites 3 to 5 with punctures clearly outlined, apical ones larger than the more densely group anterior ones; impunctate margins at most about three times width of largest adjacent primary punctures. Length 4.5 to 5.5 mm.

DISTRIBUTION.—Nagano-ken, Gifu-ken, Kanagawa-ken, Honshyu, Japan; Suigen, Chosen (Korea).

TYPE AND ALLOTYPE.—Cat. No. 51086, U. S. National Museum; Type, female, Ueda, Nagano-ken, Japan, September 19, 1931 (H. Sugiura); allotype, male, Kagamigahara, Gifu-ken, Japan, October 1, 1931 (H. Sugiura).

PARATYPES.—Deposited in the collection of the U. S. National Museum: Two females and one male, Japanese Beetle Parasite Experiment, August 12, 1933. Deposited in the Academy of Natural Sciences of Philadelphia: Three females and two males, Japanese Beetle Parasite Experiment, August 12, 1933. Retained in the collection of the Japanese Beetle Laboratory: Three females, Suigen, Chosen, August, 1923 (C. P. Clausen), and two males, Japanese Beetle Parasite Experiment, August 12, 1933.

Specimens labeled Japanese Beetle Parasite Experiment emerged at the Japanese Beetle Laboratory at Moorestown, N. J., from cocoons reared and shipped by the field station in Japan. The diagnostic characters of the females of *T. homoncularis* and *T. agilis* are very similar. The most noticeable difference lies in the extent of the impression anterior to the transverse band of punctures on the first tergite. In *T. agilis* (also *T. asericæ*) the impression can be discerned extending diagonally forward from the median portion of the transverse band of punctures and at a slight angle to it, while in *T. homoncularis* the impression is discernible only in limited areas anterior to the lateral extremities of the transverse band of punctures.

In *T. homoncularis* the front, while polished, may be seen to be very faintly shagreened if viewed in a strong light. The front in *T. agilis* shows no shagreening.

The outstanding character differences between the male of *T. homoncularis* and that of *T. malayana* are in the tegulæ, which in the former are very thin, transparent, red, and show no shagreening while those of the latter are reddish to opaque black and are shagreened. They also exhibit a shallow but distinct groove along the posterior margin which is lacking in the case of *T. homoncularis.*

The region immediately anterior to the transverse band of punctures on the first tergite is much more abruptly impressed in the males of *T. malayana* than in those of *T. homoncularis.* In the former a distinct ridge is noticeable paralleling the trans-

verse band of punctures for almost its entire length. The male of *T. homoncularis* lacks this ridge except to a barely noticeable degree at the very extremities of the transverse band of punctures.

T. homoncularis has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 16.

Tiphia Juliana new species

FEMALE.—Vertex with a few series of primary punctures of second-degree density extending through and behind ocellar triangle, primaries denser medially than on either side. Front polished; groove present though frequently interrupted; primary punctures sparse, slightly more numerous on anterior third where they intermingle with scattered secondaries in even distribution from eye to eye, primaries chiefly of second-degree density except broadly on median upper front where density is of third-degree. Clypeal extension with its impunctate apex defined by an irregular row of coarse punctures, its longitudinal extension about one-third of the distance from apex of clypeus to edge of antennal fossa. Flagellum of antenna fulvous beneath. Punctures on dorsum of pronotum slightly more dense medially where primaries and secondaries mingle than on either side, secondaries elsewhere on dorsum of pronotum sparse but well differentiated. Sides of pronotum striate, without a groove across the center, but with striations in this region sometimes increased to short, shallow, irregular grooves. Scutum with its notauli and its antero-medial groove continuous or nearly so. Metanotum densely beset with primary and secondary punctures on its periphery, with its largest discal punctures nearly as large as those of the scutellum. Legs with major calcarium of hind tibiæ widest at the band near middle; hind basitarsus with groove, shallow and extending about one-half the length of the joint, a group of three lanceolate spines on outside, one of which is apical. Tegula thin, red, polished, transparent. Wings slightly smoky. Propodeal areola with hastate outline, two and one-half to three times as long as its anterior width, median carina incomplete. Lower portion of sides of propodeum shagreened, no patch of microscopic, appressed hairs. Posterior aspect of propodeum coriaceous, median carina weak and flattened, rarely complete. First abdominal tergite with well developed preapical band of punctures the lateral portions of which have the punctures more or less coalesced in sharp depression, median punctures of band single and well differentiated. First sternite with lateral grooves on posterior half, and a few scattered punctures anteriorly. Tergites with polished impunctate margins, medially about 3 to 4 times width of largest bordering punctures. Pygidium uniformly reticulato-punctate on basal half; apex smooth but not polished. Length 8 to 8.5 mm.

MALES.—Vertex with primary punctures everywhere of third-degree density. Front with rather small primary punctures, lacking usual patch of

punctures on lower front; preocellar patch on upper half very wide, with primary punctures of irregular second-degree and third-degree density, and with interspaces broader than an ocellus; secondary punctures very dense below, not well differentiated from primaries on area where both primaries and secondaries occur, ascending half way to lowest ocellus medially and about one-third the way along the eyes. Antennocular distance about equal to width of antennal fossa. Clypeal extension with its apical width four-fifths of the distance from apex of clypeus to edge of antennal fossa; disk flat and not protruding; apex shallowly emarginate, lacking an impunctate margin, but with a thick edge. Pronotum with primary punctures small, fairly well outlined, largely of third-degree density; a few secondary punctures close to carina. Side of pronotum finely striate without a definite medial groove. Mesepisternum with small, sparse, well outlined primary punctures denser on the upper half, secondaries everywhere at least as numerous as primaries except on small callosity above coxa, densest along the finely crenulate groove bordering prepectus and next to impunctate posterior margin. Scutellum, except medially, with impunctate apex not as wide as largest apical primary punctures. Metanotum with dense secondary punctures apically, elsewhere with sparse primaries nearly equaling the largest of the scutellum in size. Tibiæ and tarsi of first two pairs of legs mostly reddish. Tegulæ polished, translucent, red. Wings with radial cell at most equaling second cubital cell. Propodeum with sides of areola converging posteriorly to give keystone shape to areola, which is about twice as long as its anterior width, lateral carinæ without bordering grooves, the median carina sinuous, the enclosed area somewhat rugose. Side with lower region not punctate or hairy but finely shagreened; posterior aspect densely hairy and coarsely coriaceous in lateral angles, with median carina on not more than lower half. First tergite with preapical band broadening laterally, where punctures become more clearly differentiated from coalesced area, uniformly, deeply impressed to lateral aspects of tergite, where the ridge on the anterior margin of the band disappears. First sternite with lateral grooves on posterior third, disk polished, impunctate between lateral grooves, coarse scattered punctures increasing in density from anterior terminals of lateral grooves toward escutcheon, until moderate-sized median keel is embraced by deep coalesced punctures. Tergites 3 to 5 moderately shagreened, with punctures extending to apex. Fifth sternite with its lateral denticle appearing more like a crescent than a tooth. Length 6 to 7 mm.

DISTRIBUTION.—Akita-ken, Iwate-ken, Yamagata-ken, Miyagi-ken, Nagano-ken, Kanagawa-ken, Honshyu, Japan; Sapporo, Hokkaido, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51087, U. S. National Museum. Type, female, Hokkaido, August 29, 1931 (K. Sato); allotype, male, Kotoni, Hokkaido, August 24, 1931 (K. Sato).

PARATYPES.—Deposited in National Museum: One female, Hokkaido, August 29, 1931 (K. Sato.) Retained in the collection

of the Japanese Beetle Laboratory; One female and one male, Makomonai, Hokkaido, August 28, 1931 (K. Sato).

In the key by Allen and Jaynes this species runs out to second alternate of couplet 37 in the key to females and to the second alternate of couplet 24 in the key to males (*T. asericæ*). The differences in diagnostic characters between *T. juliana* and *T. asericæ* are much more apparent in the female than in the male. The impunctate apex of the pygidium of the female *T. juliana* is smooth but not polished and lacks the impunctate emargination which characterizes the polished impunctate apex in the pygidium of *T. asericæ*. The second intercubital vein of female *T. juliana* is practically straight while that of *T. asericæ* is sinuous.

The males of *T. juliana* show a more uniform first-degree primary punctation on the dorsum of the pronotum than that exhibited by the males of *T. asericæ*.

T. juliana has been known in the past to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 24.

Tiphia isolata new species

FEMALE.—Vertex with a few punctures of second-degree density just behind ocellar triangle and narrowly along upper eye orbits, punctures elsewhere of sparse third-degree density. Front polished, median carina usually pronounced, shallow median groove extending upward from median carina varying distances toward ocellar triangle; primary punctures denser in area immediately above bases of antennæ than on either side, largely of second-degree density on lowest third and upward along the eyes, of distinctly third-degree density in preocellar area, where there are impunctate interspaces at least as broad as an ocellus. Antennæ uniformly dark brown with silvery pubescence. Clypeal extension with longitudinal extension of impunctate margin about one-third of the distance from apex of clypeus to edge of antennal fossa. Pronotum with transverse carina complete, primary punctures uniform in size and distribution, transverse discal band of punctures rarely present, density chiefly of second degree and third degree; secondary punctures sparse across dorsum of pronotum, frequently of second-degree to third-degree density on lateral disks and narrowly along transverse carina; impunctate area with a median prolongation of varying width, which makes the punctate portion narrower medially than the impunctate portion. Sides of pronotum without any groove across center, finely and uniformly striate over entire flat surface of the sclerite. Metanotum finely punctate on its periphery, the largest punctures much smaller than any on scutellum, median area with scattered microscopic punctures. Legs with major calcarium of hind tibiæ not abruptly bent or wider near middle than at base; hind basi-

tarsus without groove, with three inconspicuous lanceolate spines in a row on outside, one of which is apical. Tegula dark reddish and semitransparent. Wings smoky. Propodeal areola vase-shaped in outline, nearly twice as long as its anterior width; median carina extending at least to lowest fifth, on each side of median carina a shorter and less clearly defined sinuous carina; enclosed area shagreened anteriorly, reticulated behind. Lower portion of side of propodeum weakly rugose, without apparent hairs. Posterior aspect of propodeum granulated, medial carina lacking. First tergite with a preapical band of punctures rather irregular as to size and arrangement, but well separated except laterally, where the band is slightly expanded and the punctures coalesced. First sternite polished, almost devoid of hair and with lateral grooves on posterior half or less. Tergites 2 and 4 with impunctate apices widest at middle, where they are at least four times as wide as the adjacent primary punctures. Pygidium reticulato-punctate on basal half; apical section wrinkled longitudinally on lateral portions, impunctate area shagreened. Length 4 to 6 mm.

MALE.—Vertex with primary punctures everywhere of third degree density, though slightly more frequent in area posterior to ocellar triangle than on either side. Front shagreened; primary punctures in preocellar area of third-degree density and with numerous interspaces as broad as an ocellus; density of primaries gradually increasing toward orbits, attaining first-degree density along their edges; secondary punctures not well differentiated, a dense patch ascending medially half way to ocellus, but less dense and not nearly so high beside the eyes. Antennocular distance equal to width of antennal fossa. Distance from apex of clypeus to edge of antennal fossa slightly greater than width of clypeal extension at its apex; punctures of clypeal extension continues to its margin, which is slightly emarginate and not flattened. Flagellum wholly black. Pronotum with small, poorly outlined primary punctures uniformly distributed and of third-degree density everywhere on dorsum of pronotum except for a narrow median impunctate emargination which divides the punctate area; secondaries slightly more numerous than primaries and interspersed with them. Sides of pronotum broadly striate, without any definite groove across its center but with striations in this region increased to short, irregular grooves. Mesepisternum beset with primary and secondary punctures over entire convex portion, the primaries at least as abundant as the secondaries everywhere except in the angle of the epicnemia below the tegula. Metanotum moderately punctate, the punctures everywhere much finer than the coarsest punctures of the scutellum. Tibiæ of first two pairs of legs red. Tegula reddish and semitransparent except at base. Wings hyaline, with radial cell at most slightly exceeding second cubital cell. Propodeal areola vase shaped, about one and two-thirds times as long as its anterior width; lower portion of sides shagreened; posterior aspect granulated, with a single row of closely set, coarse punctures along the polished, impunctate transverse carina, median carina incomplete. First tergite with a preapical band of irregular punctures which is about one puncture wide at middle and broadening laterally, all punctures clearly defined. First sternite

with lateral grooves on posterior half or less, disk polished, median keel faintly discernible entire length of sternite to posterior sulcus, although the raised portion of the keel extends less than half this distance. Tergites 3 to 5 with rather fine, poorly outlined punctures; impunctate margin medially scarcely three time the width of largest adjacent punctures. Length 4.5 to 5.5 mm.

DISTRIBUTION.—Kanagawa-ken, Hyogo-ken, Nagano-ken, Honshyu, Japan; Oita-ken, Kumamoto-ken, Miyazaki-ken, Kagoshima-ken, Kyushu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51088, U. S. National Museum. Type, female, Yokohama, Japan, October 12, 1932; allotype, male, Yokohama, Japan, September 10, 1932 (L. B. Parker).

PARATYPES.—Deposited in the collection of the U. S. National Museum: One female, Yokohama, Japan, October 12, 1932; one male, Yokohama, Japan, September 10, 1932 (L. B. Parker). Deposited in the collection of the Academy of Natural Sciences of Philadelphia: Two females, Yokohama, Japan, October 12, 1932; one male, Yokohama, Japan, September 10, 1932 (L. B. Parker). Retained in the collection of the Japanese Beetle Laboratory: Two females, Yokohama, Japan, October 12, 1932; one male, Yokohama, Japan, September 10, 1932 (L. B. Parker).

The female of *T. isolata*, n. sp., keys out, in Allen and Jaynes' key, to the second alternate of couplet 7, which is *T. lyrata*, but *T. isolata* differs substantially from that species. The male of *T. lyrata* is not known and therefore the male of *T. isolata* can not be compared with it. When Allen and Jaynes' key is used for the male of *T. isolata* the nearest couplet for which it qualifies is No. 24, which is *T. agilis*. This at first seems awkward, since *T. agilis* and *T. lyrata* are members of two different groups as set up by Allen and Jaynes, but since *T. lyrata* is represented in the key only by the female, the male of its relative *T. isolata* would naturally fall into the couplet designating the species which the male next most nearly resembled, regardless of the group to which it belongs. The female of *T. isolata* may be distinguished from that of *T. lyrata* by the shagreening on the impunctate apex of the pygidium. The pygidia in the females of both species are wrinkled longitudinally, but that of *T. lyrata* shows no distinct shagreening on the impunctate portion while in *T. isolata* shagreening is present and distinctly so in the im-

punctate emargination. The female of *T. lyrata* also has, on the fourth tergite, a vestigial row of minute punctures extending dorsally over the center of an otherwise impunctate apex, which character is absent in the females of *T. isolata.*

The males of *T. isolata* and *T. agilis* differ in that there is an abrupt impression immediately anterior to the transverse band of punctures on the first tergite of *T. agilis,* which impression is very slight in *T. isolata* and lacking entirely in abruptness.

T. isolata has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 25.

Tiphia corpulenta new species

FEMALE.—Vertex usually without minute punctures dorsally, rarely with a few along median line; with primary punctures denser just back of ocelli than on either side, mostly of second-degree density, with irregular impunctate areas laterad of outside ocelli. Front with punctures not denser on anterior half than elsewhere, everywhere of second-degree density, with occasional impunctate areas as broad as lowest ocellus. Clypeus with its lateral margin usually distinctly convex; impunctate margin defined by an irregular row of punctures, its length at least two-fifths of distance from apex of clypeus to edge of antennal fossa. Mandibles with a shallow but uninterrupted groove. Pronotum with its transverse carina complete; punctures of variable size; primary punctures confined chiefly to the irregular transverse discal band and to a medial patch anterior to it; the transverse discal band containing several punctures in its dorsal aspect which are much larger and deeper than any other punctures on the pronotum; punctures anterior to transverse discal band and on each side of median patch largely true secondaries and distinctly of third-degree density. Side of pronotum with a definite groove across the center merging with a series of anastomosing grooves anteriorly; conspicuously striate in ventral corner, with a few punctures along dorsal border. Metanotum with a shallow median impression; size of punctures variable, with maximum density along posterior edge, the larger punctures not nearly equal in size to the largest punctures of the scutellum. Legs with major calcarium of hind tibia distinctly widest at bend near middle; hind basitarsus with a deep groove and 3 or 4 lanceolate spines on the outside, one of which is apical. Tegula with inner hind corner not produced in a broad angle, only sparsely hairy, with no hairs extending far above tegula when viewed from opposite side. Wings smoky; first cubital mark vaguely defined. Propodeal areola with sides nearly parallel, two to two and one-half times as long as wide, its carinæ narrow and usually bordered by well developed grooves; median carina becoming less distinct posteriorly and ending at least one-fifth the distance before posterior limit of areola. Lower portion of sides of propodeum shagreened, with a patch of

very fine hairs posteriorly. Propodeal slope without well developed punctures; median carina flattened and usually confined to lowest two-thirds. First abdominal tergite with its transverse preapical band of punctures varying from one puncture wide at the center to several punctures wide at its lateral extremities, not in a depression and with most of the punctures separated. First sternite with uninterrupted lateral grooves extending over not more than posterior half of sternite, and with scattered shallow punctures confined to lateral portions of posterior half. Tergites with punctures slightly farther from apex medially than laterally; impunctate border of tergites 3 and 4 two to four times as wide as hindmost primary punctures. Pygidium densely reticulato-punctate on basal three-fifths; impunctate apex with numerous wrinkles, broadly shagreened on impunctate portion. Length 14 to 15 mm.

MALE.—Vertex with postocellar area densely beset with primary and secondary punctures, each present in second-degree to third-degree density. Front faintly shagreened, with primary punctures on lower portion sparser and more limited in distribution medially than along eyes; preocellar area with numerous large interspaces, some as broad as an ocellus; secondary punctures forming a dense patch on lower third, extending upward slightly more medially than near the eye. Antennocular distance and width of antennal fossa approximately equal. Clypeal extension with its apical width slightly over one-half as great as distance from apex of clypeus to edge of antennal fossa; apex shallowly emarginate; margin polished, impunctate and slightly upcurled. Pronotum with primary punctures somewhat denser medially than on humeri, mostly of third-degree density; secondaries widely and sparsely distributed. Side of pronotum finely striate, with a strong, uninterrupted groove across its center. Mesepisternum with primary punctures deep and clearly outlined, everywhere of third-degree density; secondary punctures much more numerous than primaries, densely studding the interspaces. Scutellum with impunctate apex at least as wide as diameter of apical primary punctures. Metanotum with a shallow median impression, densely punctate, with primary punctures nearly as large as those of scutellum. Tegula black, with a definite though fine impression along outer margin. Wings with radial cell and second cubital cell equal in apical extension. Propodeum with its areola from one and one-fourth to one and one-half times as long as its anterior width, its sides slightly convergent posteriorly, and convex rather than concave, the median carina bordered by wide, shallow, crenulate grooves and ending in irregular sculpturing of varied proportions well before apex of areola, enclosed area irregularly and transversely rugose and granulate; lower portions of sides densely shagreened; posterior aspect granulate, the minute punctures poorly outlined, the median carina developed on the lower half or more. First tergite with preapical band of punctures widening laterad of the center, its anterior margin abruptly impressed, only the hindmost punctures in the band well differentiated. First sternite with apical fossa obsolete; disk polished, impunctate on area enclosed between two lateral grooves which extend, slightly incurving, over posterior half of sternite; median keel weak, bordered by shallow crenulate grooves and flanked by

irregular coarse punctures extending anteriorly from terminals of lateral grooves. Tergites 3 to 5 usually shagreened; punctures deep, with clearly outlined margins; impunctate margins absent, or at most only as wide as the diameter of the largest adjacent primary punctures; denticle on fifth sternite appressed, its elevated margin moderately long, crescent shaped, and nearly parallel to apex of sternite, frequently with smaller denticles similarly located on the fourth and third sternites. Length 11 to 12 mm.

DISTRIBUTION.—Oita-ken, Kumamoto-ken, Kyushu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51089, U. S. National Museum. Type, female, Kuju, Oita-ken, Kyushu, Japan, September 10, 1931; allotype, male, Kujyu-mura, Oita-ken, Japan, September 10, 1931 (K. Sato).

PARATYPES.—Deposited in the Academy of Natural Sciences of Philadelphia: One female, Kujyu-mura, Oita-ken, Kyushu, Japan, September 9, 1931, and one male, Kujyu-mura, Oita-ken, Kyushu, Japan, September 10, 1931 (K. Sato). Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: One female, Kujyu-mura, Oita-ken, Kyushu, Japan, September 10, 1931, and one male, Kuju, Oita-ken, Kyushu, Japan, September 10, 1931 (K. Sato).

In the publication by Allen and Jaynes this species runs out to the first alternate of couplet 32 in the key to females and to the second alternate of couplet 19 in the key to males (*T. phyllophagæ*). The female of *Tiphia corpulenta* differs from the female of *T. phyllophagæ* in that, generally speaking, it is larger than *T. phyllopagæ* and has definite shagreening on the unwrinkled portion of the impunctate apex of the pygidium; whereas the shagreening in the case of *T. phyllophagæ* is confined to the wrinkled portion. The lateral margin of the clypeus in the female of *T. corpulenta* is usually distinctly convex while in *T. phyllophagæ* it is straight.

MALE.—The males of these two species are very similar in appearance, with the exceptions that in *T. corpulenta* the impunctate apex of the scutellum is at least as wide as the diameter of the apical primary punctures, and the sides of the propodeal areola are convex, while in males of *T. phyllophagæ* the impunctate apex of the scutellum is not as wide as the diameter of the apical primary punctures, and the sides of the propodeal areola are slightly concave.

T. corpulenta has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 26.

Tiphia mediocris new species

FEMALE.—Vertex usually without minute punctures dorsally, rarely with a few along the medial line; with primary punctures denser just back of ocelli than on either side, mostly of second-degree density, with irregular impunctate area laterad of outside ocelli. Front with primary punctures not denser on anterior half than elsewhere; everywhere of second-degree density, without pronounced impunctate areas. Clypeus with its lateral margin straight; impunctate margin of extension defined by an irregular row of punctures, its length two-fifths the distance from apex of clypeus to edge of antennal fossa. Mandibles with a rather shallow but continuous median groove. Pronotum with its transverse carina usually complete, though weakly developed; punctures of variable size, secondaries not well differentiated from primaries; primary punctures densely grouped in a very distinct though irregular discal band and in a small medial patch, on each side of which they become somewhat smaller and less dense; punctures in angle of discal band just anterior to tegula approximately the same size as others in the band; punctures in lateral disk largely true secondaries. Sides of pronotum with a definite groove across center merging with less conspicuous anastomosing grooves anteriorly; conspicuously striate on ventral corner, with a few punctures along dorsal border. Metanotum usually with a shallow median impression; posteriorly beset with dense primary and secondary punctures, the larger punctures not nearly so large as those of the scutellum. Legs with major calcarium of hind tibia having a distinct bend near middle, where calcarium is slightly wider than at base; hind basitarsus with a groove and with 3 or 4 lanceolate spines on the outside, one of which is apical. Tegula with inner hind corner not produced in a broad angle, sparsely hairy, with no hairs extending far above tegula when viewed from the opposite side; with a short, shallow impression on the outer anterior margin. Wings smoky; first cubital mark vaguely defined. Propodeal areola with sides nearly parallel, two to two and one-half times as long as wide; its carinæ narrow, bordered by well developed grooves; median carina well developed but ending just before posterior margin. Lower portion of sides of propodeum mostly shagreened, without any patch of very fine hairs posteriorly. Propodeal slope without any well-defined punctures; median carina broadly flattened on top and extending over lower four-fifths. Transverse preapical band of first tergite at most one puncture wide, sometimes with small impunctate space medially, becoming wider laterally, not in a depression, most of the punctures separated. First sternite with lateral grooves on posterior half or less, with shallow punctures extending from anterior angle along sides of disk to vicinity of ends of lateral grooves. Tergites 3 to 5 with punctures noticeably farther from apex medially than laterally, where impunctate width is from two to four times the diameter of the largest adjacent punctures. Pygidium reticulato-punctate on basal three-

fifths; impunctate portion with numerous wrinkles nearly to apex, wrinkled portion also shagreened. Length 9.5 to 12 mm.

MALE.—Vertex with secondary punctures adjacent to occipital declivity forming a dense patch almost as wide as base of ocellar triangle; primary punctures penetrating ocellar triangle from behind, where they are of first-degree density; punctation each side of ocellar triangle of third-degree density except in a line along eye orbits, where they are of first-degree density. Front faintly shagreened in strong light; primary punctures on lower front very sparse medially, increasing in density toward the eye orbits, where they are at least as numerous as the secondaries; preocellar area with interspaces at least as broad as an ocellus; secondary punctures forming a dense patch on lower third, from which they extend upward in diminishing numbers, this decrease being more pronounced medially than in the region about the eye. Median groove present. Antennocular distance about equal to width of antennal fossa. Clypeal extension with its apical width four-sevenths to two-thirds as great as distance from apex of clypeus to edge of antennal fossa; apex slightly emarginate, with its impunctate margin lightly shagreened. Antennæ wholly black. Pronotum not shagreened; punctures mostly of third-degree density; secondary punctures sparse and widely scattered, slightly more numerous in a broken line just posterior to transverse carina; sides of pronotum with strong central groove frequently interrupted, sides above groove impunctate, finely and uniformly striate. Mesepisternum with its clearly defined primary punctures everywhere of third-degree density; secondary punctures much more numerous than primaries, and densely intermingled with them; premarginal groove along posterior surface lacking except on basal fifth, where it is definite but not deep. Scutellum with impunctate apex at least as wide as diameter of apical primary punctures. Metanotum densely punctate, with primary punctures nearly as large as those of the scutellum. Tegula black and polished but in strong light showing faint longitudinal striations, not shagreening; inner angle of posterior margin with definite groove formed by faintly depressed area. Wings with radial cell usually equaling second cubital cell in apical extension. Propodeum with its areola one and one-fourth times as long as wide, its sides straight but convergent posteriorly, the median carina heavier than the lateral carinæ and flattened on top, ending before apex of areola, enclosed area irregularly and transversely rugose and granulate, lower portion of sides densely shagreened; posterior aspect granulate, the minute punctures poorly outlined, median carina present on lower half or more. First tergite with preapical band wide, its anterior margin abruptly impressed, expanding somewhat laterally, punctures well differentiated only on posterior border. First sternite with posterior half of disk polished, lateral grooves on lower half or less, anterior angle with short median keel flanked by deeply crenulate grooves, numerous large, shallow punctures scattered over anterior half of disk and nearly meeting anterior end of lateral grooves. Tergites 3 to 5 shagreened, punctures deep and clearly defined, impunctate margins absent or at most no wider than the diameter of largest adjacent primary punctures. Denticle of fifth sternite of usual size and shape. Length 8.5 mm.

DISTRIBUTION.—Oita-ken, Kumamoto-ken, Miyazaki-ken, and Kagoshima, Kyushu; Nagano-ken and Gifu-ken, Honshyu.

TYPE AND ALLOTYPE.—Cat. No. 51090, U. S. National Museum. Type, female, Kagamigahara, Gifu-ken, Japan, September 30, 1931; allotype, male, Kagamigahara, Gifu-ken, Japan, October 1, 1931 (H. Sugiura).

PARATYPES.—Deposited in the collection of the U. S. National Museum: One female, Ueda, Nagano-ken, Honshyu, Japan, September 9, 1931 (H. Sugiura). Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: One female and one male, Kagamigahara, Gifu-ken, Honshyu, Japan, October 1, 1931 (H. Sugiura).

Closely allied to *T. ovinigris* and *T. phyllophagæ* in general diagnostic characters as set forth in the key by Allen and Jaynes, *T. mediocris* was at first suspected of identity with *ovinigris* but a close study revealed a number of characters sufficiently different from those of either *ovinigris* or *phyllophagæ* to justify its recognition as a new species. Since the male of *T. ovinigris* is not known, it is possible, as exemplified by other species closely related to one another, that the male of that species may, when described, be inseparable from that of *T. mediocris*. In the female of *T. mediocris* the lateral grooves on the first sternite are confined to the posterior half or less; the median carina of the propodeal areola is bordered by deep grooves; the outer anterior margin of the tegula is not produced and has no tendency to upcurling but shows a short, poorly defined impression. These characters differ from those of *T. ovinigris* in that the lateral grooves on the first sternite of the latter are complete to near its anterior apex, and the outer anterior margin of the tegula is slightly produced, has a tendency to upcurling, and is devoid of any impression.

The apex of the clypeal extension in the male of *T. mediocris* is acutely though not deeply emarginate, and the lower half of the front very lightly shagreened. In *T. phyllophagæ* the apex of the clypeal extension is shallow and roundly emarginate, and the lower half of the front is devoid of shagreening.

T. mediocris has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 27.

Tiphia burrelli new species

FEMALE.—Vertex with several patches of primary punctures of first-degree density, the largest extending upward from occipital region and invading ocellar triangle; secondaries scattered sparsely over dorsum; usually with minute punctures intermingled with primaries extending in an irregular linear series upward toward ocelli from occipital region. Front with primary punctures of first-degree density on lower half, upper half of mixed second-degree and third-degree punctation except along upper orbits, where punctures are of first-degree density, at times coalescing. Antennocular distance one and one-half times width of antennal fossa. Clypeus with its impunctate longitudinal extension about two-fifths as great as the distance from its apex to the edge of the antennal fossa. Mandibles without median groove. Antennæ fulvous beneath. Pronotum with its transverse carina complete though not strongly developed; dorsum not shagreened and with fairly well differentiated transverse discal band of punctures; primary punctures sparse, everywhere anterior to the transverse discal band except for a medial patch where density is of first degree to second degree; punctures on lateral disks sparse and largely secondaries. Side of pronotum with a definite groove across its center, polished but finely striate above, a few well defined punctures occurring on anterior half. Scutum with its notauli and antero-medial groove nearly continuous. Metanotum beset with primary and secondary punctures, its largest punctures nearly as large as those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with a deep groove, and with 3 to 4 lanceolate spines on the outside, one of which is apical. Tegula black, polished, and with inner posterior angle produced and densely pilose, with several suberect hairs arising above tegula when viewed from across the dorsum. Wings smoky; first cubital mark vaguely defined; second intercubital vein sinuous; stigma about twice as long as wide, its posterior angle truncate and not produced. Propodeal areola with sides nearly parallel; median carina complete and bordered by shallow crenulate grooves; enclosed area uniformly granulate. Lower portions of sides of propodeum shagreened and bearing dense minute hairs. Posterior aspect of propodeum with median carina not broadly flattened, extending upward over lower half or more. First abdominal tergite with a preapical band of punctures one to two punctures wide at center, widening laterally into depressed patches of coalesced punctures; hindmost punctures only, in band, differentiated. Anterior slope of first tergite devoid of medial patch of minute punctures. First sternite with lateral grooves on posterior half; lacking any definite median keel. Second and third tergites with punctures on dorsum at most but little farther from apex medially than on either side; impunctate band two to three times as wide as diameter of adjacent primary punctures. Pygidium densely reticulato-punctate on basal three-fifths; with deep impunctate emargination from the impunctate apex. Length 15 to 16 mm.

MALE.—Vertex with primary punctures denser in a patch which invades ocellar triangle from behind than on either side. Front shagreened. Pri-

mary punctures in preocellar area of third-degree density, with one or more interspaces at least as wide as an ocellus, primaries becoming more numerous toward orbits, where density is of first degree; lower front with primary punctures gradually diminishing in size but without a well defined bipunctate area, punctures of uniform first-degree density over entire lower half except on slope bordering antennal fossa above. Antennocular distance slightly less than width of antennal fossa. Clypeal extension protruding, deeply emarginate, lacking any well defined impunctate margin; disk almost flat; apical width about four-fifths as great as distance from apex to edge of antennal fossa. Pronotum with dorsum shagreened; primary punctures everywhere of uniform third-degree density except in angle just anterior to tegula, where density is of second degree; secondary punctures not numerous, sparsely scattered among primaries. Side of pronotum with a well defined groove across the center, faintly striate but devoid of other sculpturing. Mesepisternum with primary punctures large and clearly outlined; secondaries less numerous than primaries everywhere except on posterior slope. Scutellum with very narrow, irregular, impunctate apical margin except for medial impunctate emargination one and one-half to two times as long as width of largest primaries. Metanotum convex, beset with primary and secondary punctures, with largest primary punctures definitely smaller than those of the scutellum. Tegula black, shagreened, with impressed line on lateral and posterior margins. Wings slightly smoky, radial cell exceeding second cubital cell. Propodeum with sides of areola parallel or nearly so, one and one-half times as long as wide; median carina incomplete and bordered by shallow grooves, enclosed area granular-reticulate; lower portion of sides of propodeum striate, a patch of microscopic hairs on posterior half; posterior slope with dense, fine, white hairs, median longitudinal carina confined to lower half or less. First tergite with its transverse band wide, poorly defined, in a broad, scarcely perceptible depression the anterior margin of which is abruptly impressed, punctures for the most part well separated. First sternite with posterior groove faintly crenulate; lateral grooves extending forward over posterior half, enclosed disk impunctate and highly polished; anterior half with median keel bordered by coarse poorly defined grooves and surrounded by coarse punctures. Tergites 3 to 5 with punctures vaguely outlined; no perceptible impunctate margins. Denticle on fifth sternite small. Hypopygium with its impunctate median stripe linear to its anterior extremity, where it tapers to a point. Length 10 to 11.5 mm.

DISTRIBUTION.—Gifu-ken, Hyogo-ken, Shizuoka-ken, Honshyu, Japan; Kagoshima-ken, Kyushu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51091, U. S. National Museum: Type, female, Kagamighara, Gifu-ken, September 25, 1932 (S. Fujii); allotype, male, Kagamigahara, Gifu-ken, September 17, 1932 (S. Fujii).

PARATYPES.—Deposited in the collection of the U. S. National Museum: One female, Kagamigahara, Gifu-ken, September 25, 1932 (S. Fujii). Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: Two females, Kagamigahara, Gifu-ken, September 25, 1932, one male, Kagamigahara, Gifu-ken, September 17, 1932 (S. Fujii).

The character differences between *T. burrelli* and its nearest known relative, *T. vernalis,* are more pronounced than is the case with any of the other six species described in the present paper. The female of *T. burrelli* may be from 15–16 mm. in length, the pronotum devoid of median longitudinal grooves on its impunctate apex but provided with deep strongly curved grooves on its sides. In *T. vernalis* the female is approximately 11 mm: long, has one or more short, indistinct, median, longitudinal grooves on the impunctate apex of the pronotum, and it is provided with numerous striæ in the upper half of sides of pronotum but lacks a definite groove.

In the male *T. burrelli* has a sharply and irregularly impressed area anterior to the lateral portions of the transverse band of punctures on the first tergite, and the tegula is distinctly shagreened; in *T. vernalis* the male exhibits neither the sharply impressed area anterior to the transverse band of punctures on the first tergite, nor shagreening on the tegula.

T. burrelli has formerly been known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohoma Laboratory Sp. No. 28.

Tiphia castaneaevora new species

FEMALE.—Vertex with a few series of punctures of second-degree density invading ocellar triangle from behind, primaries denser medially than either side. Front highly polished; groove present though frequently interrupted; primary punctures sparse, denser on anterior third, where they are evenly distributed between the eyes, chiefly of second-degree density except across expanse of upper front, where density is of third degree. Impunctate apex of clypeal extension poorly defined by a row of coarse punctures, its longitudinal extension about one-third the distance from apex of clypeus to edge of antennal fossa. Flagellum of antenna fulvous beneath. Pronotum with its primary punctures nearly uniform in size; no definite transverse discal row or medial patch of punctures; secondary punctures sparse but well differentiated, widely scattered; medial longitudinal extension of punctate area slightly less than that of impunctate area. Side of pronotum without a

groove across the center, but with striations in this region sometimes increased to short, shallow, irregular grooves. Scutum with its notauli and antero-medial groove continuous or nearly so. Metanotum densely beset with primary and secondary punctures on its periphery, with its largest discal punctures much smaller than those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with groove, shallow and extending about one-half the length of joint, a group of three lanceolate spines on outside, one of which is apical. Tegula dark red and usually translucent on posterior half. Wings slightly smoky. Propodeal areola almost rectangular, two and one-half to three times as long as wide; carina narrow and uniform, bordered by conspicuous grooves; median carina on lowest three-fourths or complete. Lower portion of sides of propodeum shagreened, with patch of microscopic, appressed hairs. Posterior aspect of propodeum usually with scattered punctures antero-medially; median carina weak and flattened, sometimes complete. First abdominal tergite with pre apical band of punctures narrow, at most slightly depressed medially, becoming more deeply depressed toward lateral extremities, where anterior margin becomes abruptly impressed, punctures usually coalesced. First sternite with lateral grooves on posterior half, and a few scattered punctures anteriorly. Tergites with polished impunctate margins medially about three to four times width of largest bordering punctures. Pygidium uniformly reticulato-punctate on basal half, with polished impunctate emarginations; apex scarcely wrinkled, and not shagreened. Length 8 to 9 mm.

MALE.—Vertex with primary punctures everywhere of third-degree density. Front with rather small primary punctures, lacking usual patch of punctures on lower front; preocellar patch on upper half very wide, with primary punctures of irregular second-degree and third-degree density and with interspaces broader than an ocellus; secondary punctures very dense below, not well differentiated from primaries on area where both primaries and secondaries occur, ascending half way to lowest ocellus medially and about one-third of the way along the eyes. Antennocular distance about equal to width of antennal fossa. Clypeal extension with its apical width four-fifths as great as the distance from apex of clypeus to edge of antennal fossa; disk flat and not protruding; apex shallowly emarginate, lacking an impunctate margin, but with a thick edge. Pronotum with primary punctures small, fairly well outlined, largely of third-degree density; a few secondary punctures close to carina. Sides of pronotum finely striate, without a definite medial groove. Mesepisternum with small, sparse, well outlined primary punctures; secondary punctures dense on upper half and bordering the prepectus and posterior margin, less numerous than primaries only on the small callosity above the coxa; no premarginal groove, though appearing shallowly impressed in certain lights. Scutellum, except medially, with impunctate apex not as wide as largest apical primary punctures. Metanotum with dense secondary punctures apically, elsewhere with sparse primaries nearly equaling the largest of the scutellum in size. Tibiæ and tarsi of first two pairs of legs mostly reddish. Tegula polished, translucent, red. Wings with radial cell slightly

exceeding cubital cell. Propodeum with areola rectangular in outline, nearly twice as long as wide, lateral carinæ without bordering grooves, the median carina sinuous, the enclosed area somewhat rugose. Side with lower region not punctate or hairy but finely shagreened; posterior aspect densely hairy, with a median carina on lower half. First tergite with preapical band narrow, deeply impressed, of nearly uniform width, its punctures fading out on surface of depression. First sternite with lateral grooves on posterior third; disk with vague punctures and a sharp median keel anteriorly. Tergites 3 to 5 moderately shagreened, with punctures extending to apex. Fifth sternite with its lateral denticle appearing more like a crescent than a tooth. Length 6.5 to 7 mm.

DISTRIBUTION.—Chiba-ken, Tokyo-fu, Honshyu, Japan.

TYPE AND ALLOTYPE.—Cat. No. 51092, U. S. National Museum: Type, female, and allotype, male, Tachikawa, Tokyo-fu, Japan, June 11, 1932.

PARATYPES.—Deposited in the collection of the U. S. National Museum: Two females and two males, Tachikawa, Tokyo-fu, June 11, 1932. Deposited in the collection of the Academy of Natural Sciences of Philadelphia: Three females and three males, Tachikawa, Tokyo-fu, June 11, 1932. Retained in the collection of the Japanese Beetle Laboratory at Moorestown, N. J.: Three females, Tachikawa, Tokyo-fu, June 11, 1932; and three males, Narashino, Chiba-ken, June 9, 1932 (S. Fujii).

This species is very closely related to *T. asericæ* A. and J. The distinguishing character in the female is the preapical band of punctures on the first tergite. In *T. asericæ* this band is sharply depressed throughout its length, while in *T. castaneævora*, n. sp., the band is depressed very little if at all medially but becomes more abruptly depressed toward its lateral extremities. The writer has not been able to find any reliable character for separating the males of the two species, though there are minor differences that, while they defy description, can be used comparatively with a fair degree of accuracy.

T. castaneævora has been previously known to workers of the Division of Japanese and Asiatic Beetle Investigations as Yokohama Laboratory Sp. No. 29.

THE GENUS STENOPOGON LOEW IN THE UNITED STATES OF AMERICA (ASILIDAE: DIPTERA)

BY STANLEY W. BROMLEY, PH.D.

Since the appearance of my key to this genus in the Annals of the Entomological Society of America, Vol. XXIV, 2, June, 1931, I have examined a large amount of material which has resulted in the addition of nineteen new species. One of these—*S. kelloggi* was described by Mr. Joseph Wilcox. I have incorporated his description in this paper. I have further revised the key to include these new species and to elucidate relationships. I am particularly grateful to Mr. Joseph Wilcox, of Puyallup, Washington, for furnishing me material and many helpful suggestions and to Mr. E. C. Van Duzee, of the California Academy of Sciences, San Francisco, Calif., for loaning material from the Academy collection. I wish to thank also, Mr. E. S. Thomas, Curator of Natural History of the Ohio State Museum, Columbus, Ohio, for allowing me the study of the Hine collection.

Stenopogon contains many species from western North America. Only one species occurs east of the Mississippi. Most are rather elongate, small-headed Robber flies. In habits, they are ravenous, feeding on insects quite large in proportion to their size; some, as *S. obscuriventris, S. rufibarbis, S. timberlakei, S. gratus,* and *S. inquinatus,* preying extensively on honey-bees. In Texas, *S. latipennis,* is said by Mr. H. B. Parks to be destructive to the hive-bee, also. The species of *Stenopogon* themselves are likely to be preyed upon by more powerful asilids, particularly the fierce *Diogmites,* which are in turn frequently captured and killed by the large species of *Proctacanthus.*

The genus *Stenopogon* as here treated contains as a subgenus *Scleropogon* Loew. While some workers consider the two genera distinct, the species of both groups are so similar in most respects and the characters on which separation is based are so trivial that I do not think a split is justifiable.

Ospriocerus Loew is closely related to *Stenopogon.* Separation of these two genera has been based largely on the length of the

third antennal segment and the fact that in *Ospriocerus* this segment usually lacks the terminal style. The latter character is however not tenable: *O. diversus* Williston has a minute style, while *O. eutrophus* Loew has a distinct demarkation at the tip of the third antennal segment. In *O. ventralis* Coquillett, the minute style is inset in the third antennal joint. The only stable character that I have found to satisfactorily separate the genera is the length of the third antennal segment. In all species of *Ospriocerus* that I have seen, the third antennal joint is three times the length of the first two together, quite appreciably longer than in any *Stenopogon* I have examined. On this basis, *Stenopogon nitens* Coquillett should rightfully belong in *Ospriocerus*. I have examined Coquillett's type at the National Museum and found that *S. nitens* Coq. is identical with my *Ospriocerus monki* (Jour. N. Y. Ent. Soc., XLII, p. 225, June, 1934). *Ospriocerus monki* Bromley therefore becomes a synonym of *Ospriocerus* (*Stenopogon*) *nitens* (Coq.).

GENOTYPE: *Asilus sabaudus* Fabricius, Entomol. System., IV, 385, 40 (1794). Central and South Europe.

KEY TO STENOPOGON SPECIES

1. "Hypopleura"* bare 2
   "Hypopleura" with hair or bristles (subgenus *Sclcropogon*) 23
2. Very small species (10–13 mm.) (California); third antennal joint somewhat oval; arista short and bristle-like; wings short and narrow 3
   Larger, more robust species; third antennal joint constricted apically; arista not so sharply differentiated 4
3. Black species *nigritulus* Coq.
   Yellowish-brown species *albibasis* Bigot
4. Mystax at least partly black, usually entirely so or the upper half black 5
   Mystax nearly, usually entirely, light-colored 8
5. Mystax all black 6
   Mystax partly light-colored . . 7
6. Bloom of mesonotum pale gray; pile of front coxæ, fore femora, beard and post-genæ straw-colored; all tibiæ darkened at tip; genitalia slightly enlarged (16–26 mm.) (California) *jubatus* Coq.
   Bloom of mesonotum brown; a darker-colored species than *jubatus* with more black hairs and bristles, the posterior portion of the mesonotum

* The small calloused sclerite immediately anterior to the halteres. This plate is really the katapleurotergite of the postscutellum. It is the "hypopleura" of Back, not Williston.

bearing mostly black hairs; the pile of the front coxæ, fore femora, beard and post-genæ white (20–21 mm.) (California) *jubatoides* n. sp.

7. Mystax black above, rest reddish-yellow (male); female with mystax mostly black; first two antennal joints together shorter than third; pile on sides of abdomen yellow; genitalia small, compact (18–20 mm.) (Mexico, Lower California) *stonei* n. sp.

Mystax black only in extreme upper portion, rest yellowish; hair along sides of abdomen whitish; abdomen black, shining; only female known (21–22 mm.) (California) *nigroverticellus* n. sp.

8. Sternopleura with a tuft of long fine pile; smaller species 9

Sternopleura without such a tuft although usually with some pile; large variable, robust species, with or without red on abdomen (20–37 mm.) (Western U. S.) (= *modestus* Loew and *morosus* Loew). *inquinatus* Loew

9. Vestiture of thorax light-colored; hairs coarse; wings small 10

Some black hairs at least on dorsum of thorax; wings larger 12

10. Vestiture straw-colored 11

Vestiture of head and thorax reddish-yellow; male genitalia dark reddish, small, compact, forceps short not bent (16–19 mm.). *propinquus* n. sp.

11. Male genitalia large, bulging, the upper appendages bent downward at tips, the lower bent upward at tips (15–22 mm.) (California). *brevivesculus* Loew

Male genitalia short, compact; abdomen shorter and stouter than in the case of *brevivesculus* (16–21 mm.) (California). *brevivesculoides* n. sp.

12. Dorsum of abdomen reddish or yellowish on most segments 21

Abdomen blackish on dorsum, except sometimes slightly reddish on last two segments (*obscuriventris* group) 13

13. Robust, unusually coarsely hairy species, particularly of thorax and base of abdomen, the hairs and bristles of which are thick, straw-yellow; all tibiæ blackish at apex (not so pronounced on first and second pairs in some females); male genitalia black, small, compact (22–24 mm.) (Coronado, California) *felis* Bromley

More slender and elongate species, not so coarsely hairy 14

14. Posterior aspect of middle femur, except extreme base, reddish-yellow; abdomen shining black, very sparsely gray pollinose;* male genitalia enlarged, black, pale-haired; posterior tibiæ blackish on distal portion; first two pairs of tibiæ entirely yellowish (21–27 mm.) (Southern California) *Wilcoxi* n. sp.

Posterior aspect of middle femur, except tip, black 15

* Throughout this paper, as well as in all my previous papers, the term "pollinose" is used in the same sense as that described by Curran in his Glossary of Terms used in Dipterology (The Families and Genera of North American Diptera, 1934, p. 489) and means "covered with 'dust' or 'bloom.'" The term does not imply a yellowish or any other color.

15. Vestiture of head, thorax, legs and base of abdomen largely reddish or reddish-yellow; pollen of abdomen brownish-gray . . 16
Vestiture of head, thorax, legs and base of abdomen straw-colored . 17
16. Male genitalia dark reddish, compact; all tibiæ reddish; (18–23 mm.) (Calif., Wash., Ore., Utah) *rufibarbis* Bromley
Male genitalia enlarged, black; hind tibiæ blackish at extreme tip (18–26 mm.) (Calif.) *rufibarboides* n. sp.
17. Mesonotum more or less brownish pollinose 18
Mesonotum more grayish pollinose . 20
18. Abdomen largely shining black with a faint blue-gray bloom; many black hairs and bristles on posterior portion of mesonotum and scutellum; posterior tibia with the distal two-thirds black; male genitalia solid black with upper forceps turned downward at tip; a small dark colored species (15–17 mm.) (California) *engelhardti* n. sp.
Abdomen either pale brown or yellow-gray pollinose . 19
19. Abdomen pale brown pollinose; all tibiæ usually yellowish, occasionally the posterior darkened toward the tip; male genitalia compact, usually dark reddish to reddish-brown in color (16–26 mm.) (Western U. S.). *obscuriventris* Loew
Abdomen faintly and thinly pale yellow-gray pollinose; male genitalia small, black, compact; tips of tibiæ dark brown or blackish, the first two pairs in the female not always darkened (19–23 mm.) (Southern Calif.) . *andersoni* n. sp.
20. Gray pollinose; large elongate species; male genitalia black or very dark brown; tips of all tibiæ darkened (22–27 mm.) (California). *timberlakei* n. sp.
Abdomen densely light gray pollinose, smaller species; male genitalia yellowish to yellowish-brown, compact; pollen of thorax generally slightly more brownish than that of abdomen; posterior half to quarter of hind tibiæ blackish, others all yellowish (16–23 mm.) (Western U. S., Kansas to Calif.) *martini* n. sp.
21. Robust species; male largely reddish-haired, vestiture of female more straw-colored; usually only broad dorsal line of abdomen reddish, sides black (15–25 mm.) (Calif.) . . *gratus* Loew
More slender species; light vestiture straw-colored . .. 22
22. Usually entire dorsum of abdomen reddish or yellowish; upper forceps of male genitalia from side-view with inner prongs extending beyond tip (15–27 mm.) (Calif.) . *californiæ* (Walker)
Upper forceps of male genitalia from side-view with no prongs extending beyond tip (19–24 mm.) (Calif.) . *californioides* n. sp.
23. Third antennal joint long; style short and compact; first posterior cell usually open 24
Third antennal joint shorter; style bristle-like 32
24. Wings black; decidedly black species with red on abdomen, the latter not obscured by a grayish bloom, but the tip and base are black (14–20 mm.) (Kans., Colo., Nebr., Texas, Mont.) . ... *cæcidinus* Williston

Wings grayish, reddish or brownish, not deep black; reddish or blackish species, if the latter, the abdomen obscured by bloom 25

25. Blackish species, gray pollinose 26
Reddish species 28

26. Short, stout species; wings gray with costal area yellowish-gray (14–17 mm.) (Texas, Kansas) *pumilus* Coq.
Larger, more elongate species 27

27. Hairs on mesonotum all pale; wings gray subhyaline, pale brownish near veins; third segment of antenna narrowed toward tip and with a longitudinal seam on lower distal portion (21–25 mm.) (Arizona and New Mexico) *arizonensis* n. sp.
Mesonotum with some black hairs on median dorsal area; wings uniformly grayish-brown; femora mostly blackish, the front with a reddish-yellow vitta on forward side (22–26 mm.) (Texas and New Mexico.) **tenebrosus* Coq.

28. Elongate species 29
Shorter, stouter species 30

29. Third antennal segment about as long as first two together; reddish-yellow species; abdomen quite slender, subpolished; wings broader than in next species, uniformly brownish or blackish (darkest in the specimens from the Southeastern U. S.); bristles and hairs of entire body sordid white, those on vertex and legs more yellowish (20–27 mm.) (Southeastern U. S. from N. Carolina to Texas and Colorado). *subulatus* (Wiedemann)
Third antennal segment almost twice as long as first two together, abdomen unusually slender; wings long and narrow; hairs and bristles yellowish; humeri, abdomen and legs light reddish-yellow; each femur with a basal black spot; thorax blackish, yellow pollinose; wings yellowish-gray (17–20 mm.) (Texas and New Mexico) *longulus* Loew

30. Thorax grayish-yellow pollinose 31
Thorax reddish-yellow pollinose; rather large robust species; bristles of body golden; femora stout (18–21 mm.) (Texas, New Mexico, Colorado) *latipennis* Loew

31. Legs all pale reddish; some black bristles on hind femora, tibæ and vertex of head; small pale species (15–16 mm.) (Rio Grande Valley of Texas) *ebyi* n. sp.
Black vitta on hind femora; hind femora and tibiæ without black bristles; larger stouter species (15–19 mm.) (Nebraska, South Dakota, Colorado) *consanguineus* Loew

32. First posterior cell closed (occasional specimens of *indistinctus* n. sp. have this cell slightly open) 33
First posterior cell wide open .. 42

33. Wholly and densely gray-white or white pollinose (the male white; the

* My previous Stenopogon keys, based on a misidentification of *tenebrosus*, do not run to this species correctly.

female gray or pale yellowish); wings hyaline; a slender elongate species with small wings (15–20 mm.) (Texas) *cinerascens* Back

Not densely white pollinose 34

34. Wings spotted with fuscous; large, yellow pollinose, robust Mexican species (20–30 mm.) *truquii* Bellardi

Wings not spotted 35

35. Small, slender species; abdomen in male dull black, in female reddish above (19–20 mm.) (Arizona) *dispar* n. sp.

Sexes similar; abdomen pollinose 36

36. Abdomen and legs entirely reddish-yellow; small species (15 mm.) (New Mexico and Arizona) *kelloggi* Wilcox n. sp.

Legs with some black and ground color of abdomen with some black, if only mid-dorsal line 37

37. Chamois leather-yellow species, the abdomen pale in ground color with only a mid-dorsal line of black (tergites with blackish anterior areas in *uhleri*) 40

Abdomen with more black in ground color 38

38. Abdomen banded with black above, the segments black with posterior margins and venter red; yellowish-gray pollinose species (20–28 mm.) (Calif., Arizona, New Mexico) *picticornis* Loew

Abdomen more pollinose, the black portions less conspicuous 39

39. Thorax grayish-yellow pollinose contrasting with abdomen which is grayish pollinose; ground color of abdomen more or less blackish; first antennal segment yellowish; a small rather robust species (15–19 mm.) (Montana, Nebraska, Colorado, Alberta) *coyote* Bromley

Grayish-yellow pollinose species with abdomen and thorax not so contrasting; abdomen proportionately longer and more slender than *coyote;* the first posterior cell closed at margin or slightly open (19–26 mm.) (Arizona, Oklahoma) *indistinctus* n. sp.

40. "Hypopleura" with stout bristles 41

"Hypopleura" with short, fine hair; antennæ black; wings hyaline; legs dark, some reddish on front and middle femora; male ventral plate divided at tip and lobes divergent (first and fourth posterior cells closed and petiolate (23 mm.) (Colorado) *uhleri* Banks

41. Style of antenna ½ length of third joint (20–30 mm.) (Texas, Kansas, Nebraska) *helvolus* Loew

Style equal in length to third joint (24 mm.) (Nebraska) *similis* Jones*

42. Brown and flesh-colored species, densely covered with gray and yellow pollen (20–23 mm.) (Mexico) *mexicanus* Cole

Reddish or blackish species 43

43. Thorax reddish with black longitudinal lines on mesonotum; wings blackish, reddish toward base; reddish species (18–23 mm.) (Texas). *texanus* Bromley

Thorax mostly blackish, grayish or yellowish pollinose; wings more hyaline 44

* I have not seen this species, but infer from the original description that it should fit here.

44. Robust species; mesonotum gray pollinose 45
Slender, elongate species; thorax with pale yellow pollen; abdomen gray pollinose; genitalia reddish; antennæ all black (17–22 mm.) (New Mexico and Arizona) *duncani* n. sp.

45. Black species; abdomen mostly blackish (19–28 mm.) (Wyoming, Idaho, Colorado, Washington, Oregon, Utah) *neglectus* Bromley
Black species; abdomen mostly reddish above (26–29 mm.) (California). *bradleyi* n. sp.

I am unable to definitely separate *inquinatus* Loew, *morosus* Loew and *modestus* Loew and prefer, for the present, to consider them all as one variable species. The males are likely to have the abdomen reddish above and the front femora reddish below and anteriorly and are thus typical *inquinatus*. Then there are gradations from abdomen partially red (*morosus*) to blackish gray (*modestus*); *modestus* and *morosus* typically have the wings light grayish brown and the front femora largely, except the tip, blackish brown. In addition, there are some male specimens of *inquinatus*, *morosus* and *modestus* which have the wings more or less whitish. I can find no striking differences in the male genitalia. *Inquinatus* is evidently a widespread common species with varying color phases, as is exhibited in several other Dasypogonine forms, *i.e.*, *Dizonias tristis*, *Saropogon dispar*, *S. combustus*, *S. abbreviatus*, and *Microstylum morosum*.

Stenopogon jubatoides new species

Total length, 20–21 mm. A dark-colored species closely related to *jubatus* Coquillett from which it may be distinguished by the general darker color, the posterior portion of the mesonotum bearing mostly black hairs, the bloom of the mesonotum brown, not pale gray, and the pile of the front coxæ, fore femora, beard, and post-genæ white, not straw-colored.

MALE. Face pale brown prunnose. Mystax and hairs of vertex black. Pile of occiput, post genæ and beard white. Thorax with brownish bloom; most of hairs of dorsal and posterior portions of mesonotum and scutellum black, a few whitish hairs on sides. Legs black; tips of femora, basal fourth of tibiæ and tarsal segments, except extreme tips, pale reddish-yellow. Hairs of front coxæ and fine pile on femora white. Wings with bases milky-white, elsewhere gray subhyaline, the venation accentuated with pale brownish. Abdomen shining black with fine white hairs along sides, mid-dorsal line with blackish hairs. Genitalia black with some brownish and some white hairs.

FEMALE. Similar, ovipositor with pale brown bristles.

Holotype, male, Mt. Diablo, Calif., July 21, 1935 (Jack Beamer) [Kans. Univ. Coll.]. Allotopotype, female, same data. Paratopotype, same data.

Stenopogon Stonei new species

Total length, 18–20 mm. A black species related to *jubatus* Coq., with the mystax black above and reddish-yellow below in the male; the mystax of the female mostly black, the first two antennal joints together shorter than the third; the pile on the sides of the abdomen yellow; the wings smoky-brown, the anal angle white in the male.

MALE. Face gray pollinose. Mystax (lower ⅔ths), beard and hairs of occiput reddish-yellow. Hairs of upper mystax, antennæ and vertex black. Thorax brown pollinose, mesonotum above with black lines bearing black hairs. Sides of mesonotum, the pleura and coxæ with golden hairs and bristles. Legs with golden hairs and bristles. Femora black with apices reddish; tibiæ reddish with black tips; tarsi and bases of claws reddish, the posterior tarsi with black tips to the segments. Wings smoky-brown, with anal angle whitish. Abdomen slender, black, shining, with golden hairs. Genitalia compact, black, with golden and some black hairs.

FEMALE. Similar, except mystax mostly black and abdomen lightly gray-brown pollinose.

Holotype, male, Ensenada, Mex., July 5, 1930 (M. W. Stone). Allotype, female, same data. Paratopotype, male, same data. [J. Wilcox Coll.]. This species was named in honor of the collector, Mr. M. W. Stone.

Stenopogon nigriverticellus new species

Total length, 21–22 mm. A black species related to *jubatus* Coq., differing in having the mystax, except the upper portion, yellow. The abdomen is shining black with whitish hairs along the sides.

FEMALE. Face grayish-yellow pollinose. Beard and mystax straw-colored. Upper portion of mystax, antennæ and vertex with black hairs. Occipital hairs sordid straw-colored. Thorax black, shining above, with scattered patches of gray pollen. Hairs on median area of mesonotum black; rest of thoracic vestiture pale straw-colored. Legs with whitish hairs and straw-colored bristles. Femora black with pale reddish tips; tibiæ pale reddish, extreme apices blackish except posterior pair, the distal half of which are black. Wings smoky subhyaline. Abdomen shining black with sordid whitish hairs.

Holotype, female, San Diego, Calif., July 7, 1929 (L. D. Anderson). Paratopotype, female, same data [J. Wilcox Coll.].

Stenopogon propinquus new species

Total length, 16–19 mm. A black species, reddish-yellow hirsute and pollinose, closely related to *breviusculus* Loew from which it is distinguished by the more reddish color of the hairs and the short, compact genitalia.

MALE. Face yellow-gray pollinose. Vestiture of head abundant, reddish-yellow. Thorax black, reddish-yellow pollinose with concolorous thickly set

reddish-yellow hairs. Wings hyaline. Legs reddish; femora black above and distal half of hind tibiæ dark reddish-brown. Hairs and bristles of legs, reddish-yellow. Claws black with red bases. Abdomen reddish with reddish hairs; tops of first four segments blackish anteriorly. Genitalia dark reddish, small, compact.

Holotype, male, Pete's Butte, July 10, 1930 (Robert L. West). Allotype, female, San Diego Co., Calif., April 13, 1914 (E. P. Van Duzee). Paratopotypes, 2 males, Pete's Butte, July 10, 1930 (Robert L. West) [J. Wilcox Coll.]. Paratypes, 2 males, 1 female, San Diego Co., Calif., June 21, 1914, August 15, 1913, April 13, 1914 (E. P. Van Duzee); 1 male, 1 female, Mok. H. Calif., June 6, 1896 (F. E. Blaisdell); male, Milbrae, San Mateo Co., Calif., Sept. 1, 1912 (F. E. Blaisdell) [Calif. Acad. Sci. Coll.].

Stenopogon breviusculoides new species

Total length, 16–21 mm. A yellowish pollinose, yellowish haired species very similar to *breviusculus* Loew, but distinguished therefrom by the shorter stouter abdomen and the entirely different male genitalia.

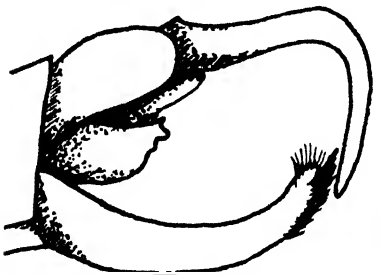


FIG. 1. Male genitalia of *breviusculus*.

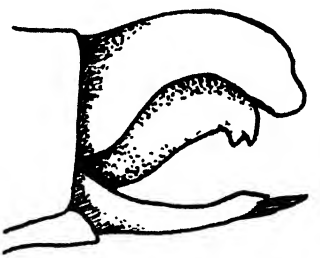


FIG. 2. Male genitalia of *breviusculoides*.

MALE. Head gray-white pollinose; vestiture straw-colored. First two antennal joints reddish-brown, third blackish-brown. Thorax yellow-brown pollinose, vestiture concolorous. Mesonotum with three dark lines. Wings hyaline. Legs yellowish-brown with concolorous hairs and bristles; upper surfaces of femora and outer aspect of hind tibiæ blackish. Abdomen comparatively shorter than in the case of *breviusculus*, yellowish-brown pollinose with concolorous vestiture. Ground color of abdomen blackish and reddish. Genitalia short, rather compact, upper forceps reddish.

FEMALE. Similar; ovipositor with reddish-brown bristles.

Holotype, male, Monterey, Calif., July 22, 1935 (Jean Russell). Allotopotype, female, same data. Paratopotypes, 2 males, 3

females, same data. Paratypes, 3 males, 5 females, Cuyama Ranch, Calif., July 25, 1935 (E. I. Beamer, R. H. Beamer, Jean Russell). Holotype and allotype in Kans. Univ. Coll., other types in Coll's. of S. W. Bromley, J. Wilcox and Univ. Kans.

Stenopogon wilcoxi new species

Total length, 21–27 mm. An elongate black species of the *obscuriventris* group with the bases and posterior part of the wings in the male broadly whitish, unique in having the posterior aspect of the middle femora (except the extreme base) reddish-yellow. The abdomen is only sparsely gray pollinose, less so in the male where it is largely shining black. The male genitalia is somewhat larger than in *obscuriventris*, is shining black, but pale haired. The first two pairs of tibiæ are entirely yellowish while the posterior is blackish on the distal portion.

MALE. Face gray pollinose. Vestiture of head, except the fine black hairs of antennæ and vertex, pale straw-colored. Thorax with pale straw-colored pollen and fine hairs, except the fine black hairs along mid-dorsal area of mesonotum. Wings hyaline; anal angle and posterior base whitish. Legs with straw-colored hairs and pale reddish bristles; tarsi with a few black bristles. Legs reddish, the basal portions two thirds to three quarters of the femora black, except the posterior aspect of the middle femur which is largely reddish yellow with the extreme base black. Tibiæ and tarsi reddish-yellow, except tip of posterior tibia which is black and the tips of the posterior tarsal segments which are blackish. Abdomen elongate, shining black, with straw-colored hairs. The genitalia are blackish, rather large and bulging; the upper appendages curved inward and downward at tip, the lower turned up.

FEMALE. Similar, but the wings gray subhyaline and the abdomen more gray pollinose.

Holotype, male, San Diego Co., Calif., July 7, 1929 (R. H. Beamer). Allotype, female, same data. Paratopotypes, 4 males, 6 females, same data (P. W. Oman). Paratypes, 1 male, 2 females, San Jacinto Mts., Calif., July 21, 1929 (L. D. Anderson); 2 females, Laguna Mts., Calif., July 6, 1929 (L. D. Anderson and P. W. Oman) [Kans. Univ. Coll.]; 1 female, Cajon Pass, Calif., August 22, 1931 (C. H. Martin); 1 male, Pine Valley, San Diego Co., Calif. (W. J. Chamberlain) [Hine Coll.]; 2 males, 2 females, Warners, San Diego Co., Calif., July 26, 27, August 1 and 2, 1921 (James) [Colo. State College Coll.]; 6 males, 5 females, Campo, Calif., August 10, 1935 (Jean Russell and Jack Beamer), 4 males, 12 females, Idyllwild, Calif., August 3, 1935 (Jean Russell), 1 male, Anza, Calif., Aug. 6, 1935 (Jack Beamer),

4 females, Jacumba, Calif., Aug. 12, 1935 (Jack Beamer) [Univ. Kans. Coll.]; 1 male, Tahquitz Canyon, Riverside Co., Calif., June 27, 1928 (E. C. Van Dyke), 2 males, 4 females, Idlewild, Calif., June 29, 1928, July 5, 1928 (E. C. Van Dyke) [Calif. Acad. Sci.].

This species was named in honor of Mr. Joseph Wilcox, of Puyallup, Wash., who has been very much interested in the Asilidae.

Stenopogon rufibarboides new species

Total length, 18–26 mm. Closely related to *rufibarbis* Bromley, but differs in having the male genitalia larger and shining black, not dark reddish.

MALE. Face gray pollinose. Vestiture of head reddish, except hairs of vertex which are blackish. Thorax black with a shining black median stripe. Mesonotum reddish-brown pollinose above, pleura gray pollinose. Wings pale brown subhyaline with anal angles whitish; base of costa with reddish-gold hairs. Coxæ and mesonotum with reddish hairs except those on median line which are black. Scutellars mostly reddish, a few black. Legs reddish-yellow with concolorous hairs and bristles; femora, except tips, black; hind tibiæ blackish at extreme tips. Abdomen elongate, slender, shining black, the incisures gray pollinose, the hairs red. Genitalia shining black with reddish hairs, enlarged and bulging, with upper appendages curving inward and downward at tip.

FEMALE. Similar, but wings all gray subhyaline, the abdomen with pollen more gray-brownish than in male. One or two black bristles in upper portion of mystax. Most of the reddish vestiture is paler than in the male.

Holotype, male, Sequoia Nat'l Park, Potwisha, Calif., 2000–5000 ft. alt., May 20, 1929. Allotopotype, female, same data (E. C. Van Dyke). Paratopotypes, 3 males, 4 females, May 12–29, 1929 (Calif. Acad. Sci.). Paratypes, 2 females, San Diego, Calif., Aug. 7, 1935 (Jean Russell) [Kans. Univ. Coll.].

Stenopogon engelhardti new species

Total length, 15–17 mm. A small, rather dark-colored species closely related to *obscuriventris* Loew, but differs in having more black hairs and bristles on the posterior portion of the mesonotum and scutellum, the abdomen largely shining black with a faint blue-gray bloom, the posterior tibiæ with the distal two thirds black, and the male genitalia solid black with the upper forceps turned downward at the tip.

MALE. Vestiture of head golden straw-colored, except hairs of vertex which are black. Thorax shining black, with brownish pollen here and there, most of the bristles of mesonotum and scutellum black. Hairs of pleura and

coxæ pale golden. Legs black except tips of femora and the tarsi and tibiæ with the exception of the posterior tibiæ, which have the distal two thirds black, entirely reddish. Femora with fine whitish pile. Wings fumose, the extreme base and anal angle milky-white. Abdomen shining black with fine scattered whitish pile and indistinct light blue-gray bloom. Genitalia small, compact, shining black, the tips of the upper forceps turned downward.

FEMALE. Similar, but scutellum with several pale bristles in addition to the black. Wings paler and without white areas. Ovipositor with dark brown spines.

Holotype, male, Jacumba, Calif., April 26, 1935 (G. P. Engelhardt). Allotopotype, same data. [J. Wilcox Coll.].

This species is named in honor of the collector, Mr. G. P. Engelhardt.

Stenopogon andersoni new species

Total length, 19–23 mm. Closely related to *obscuriventris* Loew, differing in having the tips of the tibiæ usually dark brown or blackish (the first two pairs in the female not always darkened), the abdomen having less pollen and that which is present of a yellow-gray color instead of pale brown, and the genitalia of the male smaller, more compact and black.

MALE. Face yellow-gray pollinose. Vestiture of head straw-colored. Thorax pale yellowish brown pollinose, vestiture straw-colored, a few black hairs on median line of mesonotum. Scutellum with pale straw-colored bristles. Legs with hair and bristles straw-colored. Wings gray subhyaline, very pale yellow-brown along vein margins, anal angle whitish. Femora, except apices, black; tips of tibiæ black; tips of segments of posterior tarsi black; rest of legs yellowish. Abdomen elongate, slender, dull black, sparsely gray-yellow pollinose with pale straw-colored hairs. Genitalia small, black, compact.

FEMALE. Similar, the abdomen more densely yellow-gray pollinose and anal angles of wings not decidedly whitish.

Holotype, male, San Jacinto Mts., Calif., July 21, 1929 (L. D. Anderson). Allotopotype, female, San Jacinto Mts., July 21, 1929. [J. Wilcox Coll.]. Paratopotypes, 2 males, same data; 1 female, June 30, 1933 (R. H. Beamer). Paratype, 1 male, Cuyama Ranch, Calif., July 25, 1935 (Jean Russell) [Kans. Univ. Coll.]. This species was named in honor of the collector, Mr. L. D. Anderson.

Stenopogon timberlakei new species

Total length, 22–27 mm. A light gray pollinose elongate species of the *obscuriventris* group, having the male genitalia blackish, the tibiæ yellow with tips black.

MALE. Vestiture of head pale straw-colored. Thorax gray pollinose with pale straw-colored hairs, some black along median line of mesonotum. Wings gray subhyaline, anal angles white. Legs with straw-colored hairs and pollen, the tarsi yellow, the tibiæ yellow with black tips, the femora black with yellow tips. Abdomen elongate, black, gray pollinose. Genitalia black; in two of the paratypes dark reddish-brown.

FEMALE. Similar, anal angles of wings not white.

Holotype, male, Brentwood, Calif., June 12, 1925 (S. W. Bromley). Allotype, female, same data. Paratopotypes, 2 males, 3 females, same data. [S. W. Bromley Coll.]. Paratypes, 1 female, Saltdale, Calif., June 19, 1932 (A. T. McClay) [J. Wilcox Coll.]; male, Jacintos Barranca, Kettleman Plains, Fresno Co., Calif., June 4, 1907 (Bradley); male, Coalunga, Fresno Co., Calif., June 9, 1907, elev. 500 ft. (Bradley); male, Buena Vista Reservoir, Calif., April 27, 1917 [Hine Coll.].

Two of the Brentwood specimens were taken with prey: a honeybee and a Pentatomid bug. This species was named in honor of Mr. P. H. Timberlake of the Riverside Experimental Station who first called this species to my attention.

Stenopogon martini new species

Total length, 16–23 mm. A pale gray pollinose species related to *obscuriventris* Loew. The abdomen is densely light gray pollinose, the male genitalia compact, yellowish to yellowish-brown, the pollen of thorax slightly more yellowish or brownish than that of abdomen. The tibiæ are yellowish, except the posterior which has the distal quarter to half black.

MALE. Black; head gray pollinose. Vestiture pale straw-colored. Thorax yellowish or pale brownish gray pollinose, the disc of mesonotum pure gray pollinose. Mesonotum with a median blackish divided line. Vestiture of thorax and legs pale straw-colored; except some black hairs on disc of mesonotum. Legs reddish-yellow, the femora except tips, black; the posterior tibia with distal half blackish. Wings subhyaline, pale brown along veins, anal angle whitish. Abdomen black, gray pollinose with sordid white hairs. Genitalia compact, yellowish-red.

FEMALE. Similar, except anal angle of wings not white, and hind tibiæ black on only distal quarter. The abdomen more densely gray pollinose.

Holotype, male, Parma, Idaho, May 13, 1934 (C. H. Martin). Allotopotype, female, same data. Paratopotypes, 17 males, 18 females, same data. Paratypes; 3 males, Klamath Indian Reservation, Bly Mts., Ore., June 23, 1933 (G. P. Engelhardt); 1 male, Hermiston, Ore., May 10, 1930 (H. A. Scullen); 1 male, "P"

Ranch, Harney Co., Ore., June 27, 1922 (W. J. Chamberlain); 1 male, 1 female, Jefferson Co., Mont., July 8, 1924 (E24–38); 1 male, 1 female, Vantage, Wash., May 20, 1932 (Wm. W. Baker); 1 male, 2 females, Durango, Colo., May 31, 1899; 1 male, 2 females, Havilah, Calif., May 16, 1930 [J. Wilcox Coll.]; 2 males, 2 females, Florrisant, Colo., June 22, 1908 (Rob.); 2 males, 1 female, Creede, Colo., 8844 ft. alt., Aug. 1914 (S. J. Hunter); 1 male, 1 female, Jefferson Co., Colo., June 26, 1913 (A. K. Fisher); 1 female, Douglas Co., Kans., 900 ft. alt. (F. H. Snow) feeding on winged ant (*Camponotus* sp.); 1 male, Las Cruces, N. M., May (Cockerell); 1 female, Reno, Nev., June 23, 1890 (F. H. Hellman); 4 males, 5 females, near Leander, Wyo., 5000–8000 ft. alt., Aug. (Roy Moodie); 1 female, Yellowstone Nat'l Park, June 24, 1930; 1 female, Kennewick, Wash., May 20, 1921 (A. L. Melander); 1 male, 1 female, Kern Co., Calif. [Hine Coll.]; 2 females, Bridgeport, Mono Co., Calif., June 23, 1929, and Mint Canyon, 6 miles west of Palmdale, Calif., Apr. 20, 1932 (E. P. Van Duzee) [Calif. Acad. Sci.]. This species was named in honor of the collector, Mr. C. H. Martin.

Stenopogon californioides new species

Total length, 19–24 mm. A slender species closely related to *californiæ* Walker from which it may be distinguished by the structure of the male genitalia. I am unable to give any characters which may definitely distinguish the females.

FIG. 3. Male Genitalia of *californioides*, side view.

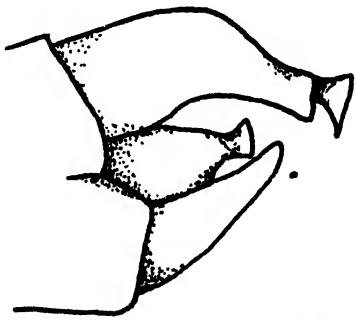


FIG. 4. Male Genitalia of *californiæ*, side view.

MALE. Head black, gray-brown pollinose. Antennæ blackish, junction of segments paler. Vestiture of head yellowish. Thorax black with pale brown-

ish-yellow bloom. Vestiture yellowish, hairs along mid-dorsal area of mesonotum black. Legs reddish-yellow, femora with black area in upper and inner portion of first four femora. Hind femora blackish on basal ⅗ths. Wings pale brown subhyaline, basal portion, particularly anal angles, milky-white. Abdomen slender, reddish above; sides and parts of first two tergites blackish. Genitalia blackish, apical prongs of hypandrium about ½ length of base.

FEMALE. Similar. Tips of hind tibiæ blackish; wings gray subhyaline. Tip of abdomen black. An occasional black hair in upper portion of mystax.

Holotype, male, Lockwood, Calif., July 24, 1935 (E. I. Beamer). Allotopotype, female, same data (Jean Russell). Paratopotypes, 7 males, 15 females, same data (E. I. Beamer, Jack Beamer, Jean Russell). Types in S. W. Bromley Coll., J. Wilcox Coll., and Univ. Kans. Coll.

Stenopogon arizonensis new species

Total length, 21–25 mm. A black species, gray pollinose, related to *tenebrosus* Coq., from which it differs in having the hairs of the mesonotum all pale and the wings are gray subhyaline, pale brownish along veins. The 3rd antennal segment is narrowed toward the tip and bears a longitudinal seam on the lower distal portion.

MALE. Antennæ long, black. Face yellow gray pollinose. Vestiture of head all whitish or straw-colored. Thorax black; gray yellow pollinose; humeri red. Vestiture of thorax and legs sordid whitish. Legs largely black, the articulations, tarsi, and a vitta on the upper inner portion of the front femora chestnut brown. Abdomen black, solid gray pollinose; incisures gray-brown (in two of the paratypes the incisures are broadly reddish-brown). Genitalia compact, narrower than the 7th segment, black in the holotype, reddish-brown in some of the paratypes. Wings gray subhyaline.

FEMALE. Similar.

Holotype, male, Albuquerque, N. M., June 27, 1931, 5000 ft. alt., (Don Prentiss). Allotopotype, female, same data (H. A. Scullen). Paratypes: male, Phoenix, Ariz., Aug. (D. K. Duncan); male, Tempe, Ariz., July (D. K. Duncan); female, Belan, N. M., Aug. 19, 1927 (L. D. Anderson) [J. Wilcox Coll.].

Stenopogon ebyi new species

Total length, 15–16 mm. A small, pale reddish-yellow species, related to *consanguineus* Loew from which it may be distinguished by the smaller size, the more slender build, the entirely pale reddish legs with no black vitta on the hind femora, the black bristles of the hind femora and tibiæ (all reddish in *consanguineus*) and the black bristles of vertex.

FEMALE. Vestiture of head pale straw-colored except the bristles of vertex, which are black, and the antennal bristles, which are dark brown. Thorax

pale chamois-yellow pollinose; all hairs and bristles whitish. Viewed from above the mesonotum with a divided median brown line on the anterior portion, curved back immediately above each humerus. An indistinct brown line on each side of this median line. Scutellum with whitish marginal bristles. Legs pale reddish with mostly black bristles on hind legs; some white bristles in addition to black on first two pairs of legs. Halteres pale reddish-brown. Wings grayish-brown, the veins towards base and their margins somewhat yellowish-red. Abdomen pale reddish-yellow, sides of segments 6 and 7, blackish.

Holotype, female, Cameron Co., Tex., June 30, 1933. Allotopotype, female, same data. Paratopotype, ♀, same data. (All collected by S. W. Bromley and Wayne Eby, in whose honor the species is named.) [S. W. Bromley Coll.] Paratypes, two females, Brownsville, Texas, April 12–May 20 (Dury) [Hine Coll.].

Stenopogon dispar new species

Total length, 19–20 mm. A rather small, slender species of the *Scleropogon* group with the "hypopleura" hairy, the first posterior cell closed and petiolate, the abdomen of the male entirely dull black, that of the female largely reddish above. The antennal style is bristle-like. The dorsum of the abdomen is not pollinose, but the thorax has a distinctly gray bloom. The legs are largely black with the upper inner aspect of the fore femora largely reddish-yellow.

MALE. Antennæ dark brown. Head with gray bloom. Mystax, palpal hairs and beard sordid whitish. Occiput and vertex with blackish-brown hairs and bristles. Thorax black with gray bloom. Humeri reddish. Mesonotum with black hairs and bristles. Scutellum with six stout black marginal bristles. Pleura partly reddish in ground color. Coxæ with sordid whitish bristles and hairs. Legs black, the bases of tibiæ, under sides of femora and bases of tarsal segments faintly reddish-yellow, very obscure in case of femora. The inner upper portion of fore femora and inner aspect of fore tibiæ reddish. Wings gray subhyaline, the anal angle milky whitish, the first posterior cell closed and petiolate. Abdomen dull black with fine scattered black hairs above and sides with a grayish-white bloom. Genitalia black with black hairs.

FEMALE. Similar, but with hairs and bristles of occiput pale yellowish and with the dorsum of the abdomen reddish. The wings are uniformly gray subhyaline, and the posterior portion of the mesonotum bears some white bristles while those of the scutellum are whitish.

Holotype, male, Patagonia, Ariz., Aug. 21, 1935 (E. I. Beamer). Allotopotype, female, same data (R. H. Beamer) [Kans. Univ. Coll.].

Stenopogon kelloggi Wilcox new species

"MALE. Length 13 mm. Head black in ground color, densely pollinose, the pollen on the occiput grayish; palpi and proboscis shining black, hairs and bristles yellowish white. First antennal joint yellowish red, 1½ times as long as second; second joint brown; first two joints with short yellow hairs; third joint and style black, third joint 1¼ times as long as first two joints together; style two-jointed, slender, one-third as long as third joint, with a minute bristle at tip. Thorax brown in ground color; humeri reddish; densely pollinose, as are coxæ; bristles yellowish-white; hypopleura bearing short bristle-like hairs. Abdomen yellowish red in ground color, except sides of first and second segments and narrowly sides of remaining segments which are black; densely pollinose; hairs and bristles yellowish white. Genitalia shining yellowish red, hypandrium emarginate at apex, the two lobes slightly divergent and slightly longer than broad. Legs entirely shining yellowish-red except for a narrow black marginal line on trochanters; claws black, narrowly yellowish at base. Halteres entirely yellowish red. Wings pale yellowish; veins yellowish red but becoming brown apically; costal fringe of spinelike hairs black beyond humeral cross vein; first and fourth posterior cells closed and petiolate, petioles about twice as long as anterior cross vein; anterior cross vein at one-third the length of the discal cell.

"FEMALE. Length 13 mm. Similar to male. Pollen of head and thorax more gray than yellowish. Apical part of sixth and remaining segments of abdomen shining yellowish red, apical spines reddish.

"*Types.* Holotype male and allotype female; Silver City, N. M., IX–16, '32 (R. T. Kellogg); in Wilcox collection.

"*Paratypes:* 47 specimens, both sexes, from type locality, X–25 and 26, '35 (R. T. Kellogg) and from Grant County, N. M., IX–24, '33 (R. T. Kellogg); and base of Pinal Mts., Gila County, Ariz., October (D. K. Duncan).

"This species is close to *coyote* Bromley, but is quite distinct from that species, in which the abdomen and legs are largely black in ground color, the first posterior cell but barely closed at the wing margin, the petiole of the fourth posterior cell shorter than the anterior cross-vein, and the fourth posterior cell large, two-thirds the length of the discal cell, while in *kelloggi* it is but half the length of the discal cell. *S. kelloggi* is smaller and is taken 2 or 3 months later in the season. The hypandria of the two species are similar."

Stenopogon duncani new species

Total length, 17–22 mm. An elongate slender species with pale yellow pollen on thorax and abdomen gray pollinose. The genitalia reddish-yellow.

MALE. Antennæ black. Face yellow-gray pollinose. Vestiture of head straw-colored. Thorax black, humeri reddish. Vestiture of thorax, coxæ and legs pale straw-colored; mesonotum with sordid yellow pollen; pleura with gray-yellow pollen. Wings hyaline with a very faint brown tint. Legs reddish-brown, the first two pairs of femora with a large black vitta above, the posterior black and the posterior tibia, except extreme base, black. Abdomen black, elongate, slender, thickly gray pollinose, ground color of incisures reddish-brown under the pollen. Genitalia compact, reddish.

FEMALE. Similar, except hind femora largely reddish below.

Holotype, male, Silver City, N. M., June 24, 1933 (R. T. Kellogg). Allotopotype, female, Silver City, N. M., June 18, 1933 (R. T. Kellogg). Paratopotype, 2 males, Silver City, N. M., June 24, 1933 (R. T. Kellogg). Paratypes: 1 female, Chiricahua Mts., Ariz., June (D. K. Duncan) (No. 30); 1 male, Beck Hall, Cambray, N. M., June, 1931; 1 female, Ajo, Ariz., Aug. 26, 1927 (J. C. Bradley); 1 female, Florence, Ariz., June 24, 1932 (D. K. Duncan); 1 female, Tempe, Ariz. (D. K. Duncan); 1 male, 1 female, Ariz., C.U. Lot 35 [J. Wilcox Coll.]; 1 female, Clark Val., Colo. Desert, Calif., May 2, 1932 (H. G.) [Calif. Acad. Sci. Coll.].

This species was named in honor of Mr. D. K. Duncan, of Globe, Arizona, who is an active collector of Asilids.

Stenopogon indistinctus new species

Total length, 19–26 mm. A grayish-yellow pollinose species with the first posterior cell closed at the margin or slightly open, related to both *helvolus* Loew and *coyote* Bromley.. From the former it may be distinguished by the ground color of the abdomen being more largely blackish and from *coyote* by the larger size, proportionally longer and more slender abdomen, and the color of the posterior aspect of the middle femora which in *indistinctus* are largely reddish-yellow while in *coyote* the black of the upper portion extends at least half-way down on the posterior aspect.

MALE. Head gray pollinose, vestiture straw-colored, becoming darker on occiput and pale orange-brown on vertex. Antennæ black with basal joint largely reddish. Thorax gray-yellow pollinose. The median dorsal marking of the mesonotum blackish and divided longitudinally by a pale line. Vestiture of thorax including scutellum straw-colored. Wings short, hyaline, the first posterior cell closed slightly before or at the margin. Legs reddish-yellow with yellow hairs and bristles, the dorsal aspect of the femora and tibiae blackish. Abdomen elongate, less robust than in *coyote*, with considerable black in the ground color, with a grayish-yellow bloom and slightly lighter colored fine hairs. Genitalia reddish with straw-colored hairs.

FEMALE. Similar, the first posterior cell more inclined to be open than in male. Ground color of abdomen, black and reddish.

Holotype, male, White Mts., Ariz., Aug. 1930 (D. K. Duncan). Allotopotype, female, same data. Paratopotypes, 2 males, 8 females, same data. [J. Wilcox Coll.]. Paratypes: 1 male, 4 females, Concho, Ariz., Aug. 18, 1934 (A. E. Pritchard); 1 male, 2 females, Kenton, Okla., June 27, 1933 (A. E. Pritchard) [A. E. Pritchard Coll.].

Stenopogon bradleyi new species

Total length, 26–29 mm. Related to *neglectus* Bromley from which it may be distinguished by the dull reddish abdomen.

MALE. Face grayish-white pollinose. Vestiture of head pale straw-colored except hairs of vertex which are dark brown. Thorax black except humeri and posterior calli which are deep reddish. Hairs and bristles of thorax, coxæ, and legs pale straw-colored, except fine hairs on mesonotum which are black, and several stout bristles on humeri, dark brown. The thorax is gray pollinose above; yellowish gray pollinose on sides. Scutellum largely dull reddish, covered with gray-yellow pollen. Legs reddish-brown, the femora with a large black vitta, one on the anterior femora on the upper caudal aspect, one on the middle femora on the forward upper side, one on the posterior femora covering largely the anterior and dorsal portions. Wings pale brown subhyaline. Abdomen dull reddish with fine short straw-colored hairs and grayish-yellow sparse pollen, thicker along sides. Genitalia reddish.

FEMALE. Similar, but the bristles on the humeri are sordid yellow instead of dark brown.

Holotype, male, Grant Forest, Calif. (6400–7000 ft. alt.) Aug. 9–13, 1927 (J. C. Bradley Coll.). Allotopotype, female, on same pin. (Evidently taken in coitu.)

This species was named in honor of the collector, Professor J. C. Bradley, of Cornell University.

BOOK NOTICE

Über entomologische Sammlungen. von Walther Horn und Ilse Kahle unter Mitarbeit von R. Korschefsky. Teil I, Seite 1–160, Tafel I–XVI, Dec. 1935; Teil II, Seite 161–296, Tafel XVII–XXVI, Oct. 1936; Teil III, Seite 297–536, Tafel XXVII–XXXVIII, Aug. 1937. Berlin-Dahlem.

The last part of this voluminous and exhaustive work, which appeared in August, 1937, brings to completion a study that was started by Dr. Horn twenty-seven years ago. Like many studies, it grew much larger than the authors anticipated. However, the entomological world should be grateful to Dr. Horn and his colleagues for their industry and perseverance, for we now have an annotated directory, as complete as it could be made, of the entomological collections and collectors, their scope, large and small, over the world. The information, which is both historical and current, is accompanied by 38 plates carrying the hand-written labels of hundreds of collectors and describers. The work should be especially valuable in locating old collections and in determining the identity of labels placed on specimens. And it is a faithful record of the activities of bygone collectors.

In the last volume, Dr. Horn has written various historical chapters dealing with the early entomological history of Central Europe, insect outbreaks, early handling of insects, first private collections, numerous entomologists, first entomological societies and publications, collections in foreign lands, scientific publications, entomological museums, history of the five greatest in Europe, beginnings of entomological museums, especially in Germany, the relation of systematic entomology to general experimental zoology, especially in Germany, the reorganization and reform of zoological museums, and with his thoughts during his forty-eight years of contacts with the museums of many lands.

This brief and inadequate notice does no more than call attention to the wealth of material in Dr. Horn's writings. Dr. Horn has many friends and admirers in the United States, and this, his most recent contribution to entomology, is assured of respect and appreciation.—H. B. W.

SOME NOTES ON COLIAS AND BRENTHIS (LEPIDOPTERA, PIERIDÆ AND NYMPHALIDÆ)

BY ALEXANDER B. KLOTS
COLLEGE OF THE CITY OF NEW YORK

This paper consists largely of the record of a collecting trip made during the summer of 1935 by Professor Herbert Ruckes and myself, through New Mexico, Colorado and Wyoming, and especially of notes and observations on the two butterfly genera, *Colias* and *Brenthis*, which I hope some day to monograph. The remainder of the butterfly material from this trip is in the collection of Mr. C. dosPassos.

Colias and *Brenthis* present problems of great taxonomic and zoögeographic interest. In common with a considerable number of other butterfly genera they are Arctic in origin, and contain many species common in greater or lesser degree to the Palaearctic and Nearctic.

There is a popular idea that our North American butterflies are very well known scientifically, but this is not so. Far less is known in detail about the butterflies than about many other groups of insects, in spite of (and possibly in part because of) the great popular interest in the group. I therefore take the present opportunity to point out important gaps in our knowledge of various species of these two genera. Probably some of these gaps may be filled by a study of specimens now in various private collections, and in museums which I have not visited; but for others collecting and life-history work will have to be done at strategic locations. Any additional information which may be made available for me will be greatly appreciated.

LOCALITIES VISITED IN 1935

To save repetition the localities in which collecting was done in 1935 are here described at some length. In a number of cases directions for reaching these are included, as these will prove of value to other collectors desirous of visiting these places, some of which are type localities.

LITTLE TESUQUE CANYON, SANGRE DE CRISTO RANGE, NEW MEXICO

The locality in which collecting was done lies at 8000–8800 ft. altitude, near the head of Little Tesuque Creek, a few miles northeast of Santa Fe. The region has recently been designated as the Hyde State Park, and an improved road is being constructed up from Santa Fe. It is in middle Canadian Zone, lying in the central part of the coniferous forest belt. In the moist valley the forest of Yellow Pine (*Pinus ponderosa*) gives way largely to firs; but on the steep hillsides, where the run-off of water is great, the pines predominate to considerably higher elevations. The majority of the butterflies are to be found in the small, grassy meadows in the valley, although some, such as *Polygonia* ssp., *Basilarchia wiedmeyeri, Pieris napi,* etc., prefer the shaded woods, and others, such as *Hypaurotis chrysalus*, prefer the thickets of Chaparral Oak (*Quercus gambeli*).

ASPEN RANCH, SANGRE DE CRISTO RANGE, NEW MEXICO

Like Little Tesuque Canyon, this locality is on the western side of the mountain range; it is a few miles further north than Little Tesuque Canyon. The environment does not differ essentially from the description above. Around Aspen Ranch many of the mountain sides were burned off, about forty years ago, I believe. The faster-growing Quaking Aspen has repopulated these areas, and is only very slowly being replaced by sparse growths of climax conifers. In June, 1935, the aspen groves were being very severely attacked by the western tent caterpillar, whole hillsides being defoliated, and the spruce bud worm was very plentiful in the conifers, so that the trees were having a hard time.

WINDSOR CANYON, COWLES, NEW MEXICO

Cowles is located nearly at the end of the road that leads north from Pecos along the Pecos River, a mile below the Panchuela Ranger Station; at this latter place we made our base camp. This is on the east side of the main Sangre de Cristo ridge, nearly opposite the localities described above. Windsor Creek flows eastward from Santa Fe Baldy Peak ("Baldy Peak" on the U. S. Topographic map, Santa Fe Quadrangle) and at Cowles joins

the upper waters of the Pecos. Up Windsor Canyon runs a Forest Service trail, with branches to Santa Fe Baldy and Lake Peaks, which leads westward across the range to Santa Fe.

Collecting at Cowles and in Windsor Canyon was done in the grassy, well-watered fields and meadows. The effect of the dry winds from the west is well illustrated by a comparison between this locality and Aspen Ranch on the western side of the range; for at the latter locality the winds, bone-dry from their passage over hundreds of miles of desert, take on moisture, while here they discharge it. As a result Cowles has a much more luxurious true Canadian Zone flora and fauna at a lower elevation than Aspen Ranch at a higher elevation. Cowles is at about 8000 ft, elevation; at Aspen Ranch Transition and lower Canadian Zone elements are found on the dry hillsides even up to 10,000 ft. It is thus seen to be moisture, and not merely temperature, that here largely determines the lower limits of the coniferous forest, although of course these two factors are largely interdependent.

SANTA FE BALDY PEAK

Along the trail up from Cowles (see above) one passes through heavy Canadian Zone coniferous and aspen forest, with occasional small, grassy meadows or "parks." Timberline on Santa Fe Baldy occurs quite abruptly at about 11,700 ft., the trees extending on comparatively gently sloping ground nearly to the margin of the small lake that lies within the curve of the cirque of the peak. Around this lake are some nearly level, grassy meadows. From here, steep, grassy or boulder-strewn slopes lead upward for several hundred feet rise in elevation to the long, curved, barren ridge of the peak. A noteworthy series of *Oeneis,* many of them quite worn, was taken on the very top of this ridge by Mr. Richard Whitmer of our party. The species has been determined as *O. brucei* Edw. by Mr. dosPassos. None of these butterflies were seen at all below the very crest of the ridge.

Santa Fe Baldy and Lake Peaks, together with Truchas and Jicarilla Peaks further north, probably represent the southernmost extension of any sizable areas of Hudsonian and Arctic Alpine Zones in the continuous Rocky Mountain chain, and so are worthy of a great deal of careful study and collecting.

ROCK CREEK, VIC. OF COLORADO SPRINGS, COLORADO

Collecting was done in the grassy meadows near the Fountain Valley School cabin, at about 8400–8800 ft. altitude. This was in the middle of typical, heavy, Canadian Zone coniferous forest, *Pinus ponderosa, Abies concolor, Picea pungens, Pseudotsuga mucronata* and *Populus tremuloides* being the dominant trees. Nevertheless, *Yucca glauca* occurs here, and such tropical butterflies as *Nathalis iole* and *Eurema mexicana* are common and well established.

HALL VALLEY, COLORADO

For directions for reaching this famous collecting locality, important because of the work of Bruce, Snow, W. H. Edwards and Barnes, I am indebted to Mr. F. M. Brown. Hall Valley is located in the extreme northwest corner of Park County, and may be found on the Montezuma Quadrangle of the U. S. Topographic maps. It can be reached from the "town" of Webster, which is located on U. S. Highway No. 285, about 14 miles west of Bailey.

Hall Valley is a long, narrow valley that extends up from lower Canadian Zone meadows at Webster, and ends in a large area of Hudsonian and Arctic-Alpine Zones. At the upper end is a striking cirque of about 11,500 ft. altitude, which is rimmed by the high ridges of the Continental Divide reaching heights of 12,500–12,952 ft. Timberline occurs in the valley floor at 10,700–11,000 ft., although growths of greatly stunted spruce push somewhat higher on some of the slopes. In the upper end of the valley are large areas of grassy meadows and low willow brush; the steep slopes of the valley sides are covered with short herbage in between areas of rocky slides; and the remnants of an ancient peneplain that form the tops of the encircling ridges are typical, Arctic-Alpine, short-grass tundra. Many bog areas occur in the valley floor, both above and below timberline, and there are frequent beaver ponds in the course of the rapid stream that flows down the valley.

I know of no more attractive locality in the Colorado Rockies than this, combining as it does accessibility with inspiring scenery and excellent high-altitude collecting. It is the type locality for a number of butterflies; and it should be an ideal place for some much-needed ecological and life-history studies.

PINGREE PARK, COLORADO

Pingree Park is a large, grassy meadow, or "park," located near the peaks of the Mummy Range, west of Fort Collins, Larimer County. It may be found on the Home Quadrangle of the U. S. Topographic maps. It is reached best by automobile road from Fort Collins, *via* Poudre River Canyon. Pingree Park lies at 9000–9500 ft. elevation, in the middle of Canadian Zone forest belt. Here, every August, is held the annual meeting of the Rocky Mountain Entomological Conference. I can well attest that a visit to this meeting will repay a visitor manyfold in knowledge gained from the scientific programs, in acquaintance with some very excellent territory, and in pleasant friendships.

MUMMY PASS, ROCKY MOUNTAIN NATIONAL PARK, COLORADO

About 8 miles from Pingree Park, from which it can be reached by trail, Mummy Pass lies at an elevation of 10,500–11,400 ft., in the extreme northern part of the Rocky Mountain National Park. Ascending from Pingree Park, the forest belt ends rather abruptly with a scattering of *Picea, Abies* and *Pinus flexilis,* so that Hudsonian Zone is rather limited. There is a very large area of grassy, Arctic-Alpine tundra, with occasional willow bogs. On the peaks (Comanche Peak, Mummy Mt., Hagues Peak and Hallett Glacier) on either side of the pass are steep, rocky slopes where vegetation often maintains a precarious foothold, and where Pikas and Ptarmigan abound. It is a long, stiff trip up from Pingree Park and back on foot, but an entomologist will be repaid by some excellent high-altitude collecting in season.

SNOWY RANGE, WYOMING

During the week of July 17–23 we stayed at the University of Wyoming Summer Camp, where excellent geological and biological laboratories are being completed. This is ideally located near the upper limit of the coniferous forest, in the Snowy Range at the northern end of the Medicine Bow Range. An excellent motor road is now being constructed westward from Laramie across the Laramie Plains to Centennial; hence it crosses the Snowy Range, passing through many miles of very beautiful Hudsonian Zone,

drops down on the west side of the range, and connects with the road to Saratoga and the Lincoln Highway at Walcott. There are now few more accessible localities in the Rocky Mountains than this, where high altitude collecting may be done at the running board of one's car, so to speak; and any entomologist who visits the Snowy Range will be well repaid for his efforts.

The season was very late here in 1935, as elsewhere also, so that during July many species were found just beginning to emerge that normally would have been flying in quantities. A return visit to the Snowy Range was paid on August 13, and much interesting data secured regarding the seasonal succession of many species.

The Snowy Range may be located on the Medicine Bow Quadrangle of the U. S. Topographic map.

MIDDLE PINEY LAKE, WYOMING RANGE, WYOMING

Reached by a rather poor road westward from Big Piney, Sublette County, Middle Piney Lake lies at 8818 ft. altitude, in about middle Canadian Zone. The grassy meadows and mountainsides around the lake offer interesting collecting; while Wyoming Peak and its surrounding buttresses, rising to considerable areas of Arctic-Alpine Zone, present some very interesting zonal distribution problems. Near the foot of the lake a very large area of slide rock has come down from the mountain to the southeast, and forms thus a continuous connection between the middle Canadian Zone meadows of the lakeshore and the Hudsonian areas on top of the mountain. A number of species that are normally found only in the rock slides above timberline have here spread downward, offering a very interesting example of intrusion. The Pika (*Ochotona*) is thus found in this rock slide surrounded at a short distance by typical middle Canadian Zone flora and fauna; and a specimen of the normally Arctic-Alpine Copper butterfly, *Lycaena snowi* Edw., was taken on a rock pile near the lakeshore. Such cases lead one to suspect that it is the immediate environment, rather than any larger "Life Zone" influence, that largely determines the distribution of such organisms. Both the species mentioned above may be termed "petrophiles," for they are seldom if ever found away from the imme-

diate neighborhood of large masses of broken rocks; and probably they will, within reasonable limits, be found wherever this type of environment occurs, regardless of minor Life Zone differences.

This does not, however, invalidate the entire Life Zone theory, as some ecologists would insist. There must be thousands of square miles of slide-rock territory in the Rocky Mountains that should be perfectly suitable for such petrophilous species as Pikas, *Lycaena snowi*, *Erebia magdalena*, etc., yet which, lying in lower Canadian or Transition Zone, will never be occupied by them. In such cases the change would be too great. These species are sufficiently adaptable to make successfully the change from Hudsonian to upper or middle Canadian Zone, and even when circumstances allow, I do not doubt, to lower Canadian. But beyond a certain limit they cannot extend. Temperature is without a doubt, a large factor in this; but there must be others. And it is the sum of all these factors that determines the ecological category which we term the "life zone." Like most sweeping ideas the Life Zone Theory has suffered as much at the hands of overenthusiastic friends as from opponents; but this is no reason for throwing it away *in toto* and descending into a welter of minor, unclassified "associations" as some ecologists would.

Wyoming Peak and Middle Piney Lake are to be found on the Afton Quadrangle of the U. S. Topographic maps.

The Wyoming and Salt River Ranges are of especial interest to the taxonomist and zoögeographer. They probably represent the southernmost limit of distribution of many northern species and subspecies which, having spread southward through the Yellowstone Park, Teton, Snake River and Hoback Ranges, are here prevented from further extension of their ranges by lack of suitable mountain connection. A road up Greys River, which lies between the Wyoming and Salt River Ranges is, I believe, in process of at least partial construction by the C. C. C.; if it does not result in bringing in a swarm of firebug tourists, this should be of great value to scientific collectors.

GREEN RIVER LAKE, WIND RIVER RANGE, WYOMING

Green River Lake, located about 50 miles north of Pinedale, is at the head of the Green River; it may be located on the Fremont

Peak Quadrangle of the U. S. Topographic maps. The lake lies at an elevation of 7958 ft. and is nearly at the bottom edge of the coniferous forest. Transition Zone sagebrush and Potentilla "flats," and grassy meadows extend up the valley bottom to the lake; and a heavy Lodgepole Pine (*P. murrayana*), Spruce and Fir forest covers the Canadian Zone mountain slopes, extending down to the shores of the lake. Trails lead from the lake up neighboring mountains, as well as into the heart of the as yet unspoiled Wind River Range. We climbed Little Sheep Mountain (alt. 10,175 ft.) on the west side of the valley, and Mt. Osborne (11,905 ft.) on the east side. Little Sheep Mountain barely reaches to timberline, but excellent collecting is to be found in the grassy meadows and parks traversed during its ascent. On Mt. Osborne the timberline occurs at about 10,500 ft. Just below timberline the spruce-Douglas fir forest gives way abruptly to a narrow, upper belt of White-barked Pine (*Pinus albicaulis*). Above this is a large area of grassy and rocky Arctic-Alpine tundra, where excellent collecting may be had. At the date we reached this no *Oenis* were flying (Aug. 5), but an excellent series of *Erebia callias* Edw. was taken, the species being sharply limited to upper Hudsonian and Arctic-Alpine Zones. *Erebia sophia ethela* Edw. was common also, but limited to Canadian Zone meadows.

To many friends, both old and new, Dr. Ruckes and I are indebted for help and advice on this trip. In particular I wish to express my appreciation of the splendid work being done by the Rangers of the U. S. Forest Service, in preserving as best they can the forests of our West, and at the same time in opening up new trails and in keeping old ones passable. Of course, too much can be done in the matter of encouraging the general public to penetrate these forest areas; the fire hazard is enormous at all times, and a careless tourist can do almost irreparable damage with one match. In some parts of the west, recent, politics-inspired, "public works" programs are in this way opening up large forest areas to the public without making adequate provision for their protection. But among the men of the Forest Service I have never failed to find a desire for true conservation,

based on knowledge gained in the field and not in a desk-chair; and the interest of these men in scientific work, and their unfailing courtesy and helpfulness, are things that I shall always remember with deep pleasure and appreciation.

Colias meadi Edwards

Large series of *C. m. meadi* were taken in the Snowy Range, July 17–23 and August 13, and at Mummy Pass, August 18 and 20, where this fast-flying species abounds in Hudsonian Zone tundra, and is somewhat less abundant in Arctic-Alpine Zone. All the July specimens were freshly emerged; in both localities collected in August the majority of the specimens taken were still very fresh, although some were rather worn.

According to my experience *m. meadi* is largely limited to the shadeless, grassy meadows at and above timberline; of many hundreds of specimens which I have taken, and of more hundreds which I have seen, but few have been in meadows of the Canadian Zone forest belt. Not only does *m. meadi* almost certainly never breed in Canadian Zone, but adults blown down below timberline lose no time in flying back up again. Probably a very strong positive phototropism or "heliotropism" is resposible for this.

Series of specimens referable to *C. meadi elis* Edw. were taken in both the Wind River Range (Little Sheep Mt., July 25–Aug. 7, and Mt. Osborne, Aug. 5) and the Wyoming Range (vic. Middle Piney Lake and Wyoming Peak, Aug. 8–12). The chief characteristics of *elis* as compared with *meadi* are as follows:

(1) greater size; (2) lighter orange ground color above, especially in the males; (3) larger size of the spots in the black marginal borders of the females; (4) less greenish-fuscous suffusion on the under side of the secondaries of the males; (5) a less well-marked discal spot on the under side of the secondaries, due to reduction in width of the purplish-pink area surrounding the spot; (6) a more northern distribution—see below.

It is probable that the Wind River, Wyoming, and Salt River Ranges mark the southern limit of distribution of *elis*, which ranges northward into Alberta and British Columbia, and possibly Alaska. The Snowy Range undoubtedly marks the northeastern limit of *m. meadi*. I have seen no material from the Uintas or other Utah localities, so cannot be sure of the northwestern limit of *m. meadi*, or the southwestern limit of *m. elis*.

More marked than most of the color and pattern differences between *m. meadi* and *m. elis* is the difference in habitat of the two races. *Elis,* though ranging as far up into Arctic-Alpine Zone as *meadi,* is at times to be found common in middle Canadian Zone meadows and parks, entirely surrounded by heavy coniferous forest. At Middle Piney Lake, numerous specimens were seen and many taken, visiting *Helianthus* blossoms in typical Canadian Zone meadows and unforested hillsides; the center of abundance of the species was, however, somewhat higher up, in lower Hudsonian Zone. The same thing was noted in the Wind River Range, and here several specimens were taken even as low as at the edge of the sagebrush plains that cover the valley floor at about 8800 feet altitude. In the course of considerable experience with *m. meadi* I have never seen this, although doubtless specimens of the latter race do occasionally stray down-mountain for considerable distances.

Colias eurytheme Boisd.

Various forms and broods of *eurytheme* were taken everywhere that collecting was done. In its zonal as well as its altitudinal range *eurytheme* is the most widespread of Nearctic Colias, occurring commonly in all Life Zones, as well as from Alaska to central Mexico. At present we are really very ignorant of the conditions which presumably influence the appearance of the various color forms, and can, with security, make only rather vague generalizations. Cold weather and high altitude have comparable effects, and in general seem to produce the forms *autumnalis* and *eurytheme.* Warmer conditions bring about an increase in size and in richness of coloration, often producing, or at least being accompanied by, *eriphyle* and sometimes small *amphidusa* specimens. Hot weather is accompanied by large, richly colored *amphidusa;* but in many localities *eriphyle* continues to emerge throughout the summer and flies in company with *amphidusa;* and even specimens referable on the basis of size and color to *autumnalis* may be found flying in such mixed company.

All of the above statements are liable to frequent exception, depending on geographic location, local environment, weather, etc., so that an enormous amount of very carefully controlled

breeding work will have to be done, under experimental conditions of temperature and humidity, before the problem can begin to be understood. I very strongly suspect that some inheritance-factors will be found to enter into the matter; but in any event it cannot be denied that *eurytheme* is extremely sensitive to changes in the physical environment, and presents a very complex and as yet quite unresolved problem.

Colias astraea Edw.

A considerable number of *C. astraea* were seen, and a small series taken, in the valley of Clear Creek just below the "Natural Bridge," near the head of the lower Green River Lake on August 3. The species appears to be extremely limited in its ecological range. All of the specimens seen were in a rather peculiar, grassy-sphagnaceous type of bog, in which small clumps of willow were interspersed. Females were seen dropping into the low herbage as if ovipositing, but no definite evidence of the accomplishment of this act was secured.

The very restricted environment in which the colony was found is of considerable interest in view of the present lack of knowledge of the relationship of *astraea* to *christina* Edw. The latter species is a Lupine feeder, but there was no Lupine in the bog where these *astraea* were taken; moreover, no *astraea* were seen in contiguous territory where Lupine abounds. I strongly suspect that *astraea* and *christina* are really distinct species, and not merely forms of a single species as is usually considered to be the case.

The whole problem of the interrelationship of *christina*, *astraea*, *alexandra*, *gigantea* and *interior*, and the identification of many specimens of these species, is at present a very puzzling one. It will probably never be resolved satisfactorily until a great deal of careful breeding work, like that of Gerould on *philodice*, has been carried out. The more one studies these species by specimens alone the more one is puzzled, for perfect series of intergrades exist between most of them; and so a large percentage of specimens from the Northwest cannot be named with any assurance.

Colias alexandra Edw.

In 1935 *alexandra* was found common in nearly every suitable locality where collecting was done. It is essentially an inhabitant

of the lower half of the Canadian Zone, although specimens frequently occur in upper Transition and Canadian Zones. It thus occupies a definitely lower zonal range than *C. scudderi*. The males show an especial fondness for mud puddles, sometimes congregating in large swarms.

Definite records for 1935 are: Windsor Canyon, Cowles, N. M., July 2, very common; Hall Valley, lower end near Webster, July 15, uncommon; vic. of Estabrook, Colo., July 12, common; Pingree Park, Aug. 18–23, common in middle to lower Canadian Zone, specimens mostly worn, some quite fresh; Foxpark, Albany Co., Wyo., July 20, common in lower Canadian Zone; Green River Lake and vic. July 24–Aug. 7, uncommon, ranging from upper Transition Zone sage flats (rare) up to meadows and "parks" in mid-Canadian Zone at about 9500 ft. alt.

The large series of specimens taken at Cowles averages considerably larger than topotypical Colorado material, but definitely belongs to *a. alexandra* and not to the Great Basin race *edwardsi* Edw. Specimens from Wyoming average a bit smaller than Colorado series, are underneath somewhat more heavily suffused with greenish-fuscous, and have more traces of a pinkish ring around the discal spot of the under side of the secondaries.

Some very thorough collecting and study is needed in order to clear up the relationship of *alexandra* and *christina*. In most parts of their common range these two species are perfectly distinct; but many specimens from Idaho, Washington and southern British Columbia cannot distinctly be named as either *alexandra* (*emilia* Edw.?) or as yellow *christina*. The intergradation of the two species in this region is all the more puzzling when we consider that from east of the Continental Divide in central Montana and northern Wyoming, *alexandra* is small and heavily infuscated beneath—not at all like the *christina* from the same region. It is possible that the two forms are really not distinct in Idaho and northern Utah; but that *alexandra* was able to extend its range southward from there into New Mexico (with an offshoot westward into California), then east around the southern end of the Rockies, and northward in the Colorado mountains to Wyoming and Montana. By the time it reached there it had differentiated greatly and hence diverged from *christina* to a point of unmis-

takable specific identity. *Christina* undoubtedly does not extend very far southward in the Great Basin region; I have specimens from Payson, Utah, but none south of that point.

Colias scudderi Reakirt

C. scudderi scudderi was taken as follows: Hall Valley, July 14, 1 fresh ♂ in upper Canadian Zone meadow; Mummy Pass, July 19, 1 ♂, 1 ♀ quite fresh specimens, in Arctic-Alpine Zone, the male flying over tundra, the female in a willow bog; Pingree Park, several males, August 18–22, all badly worn; Snowy Range, July 17–23, and Aug. 13, common.

In the Snowy Range in July the species was rather common in small, grassy meadows and glades somewhat below the upper edge of the coniferous forest belt, and was only rarely present in the larger, more open, tundra and meadows in Hudsonian Zone. The majority of specimens taken at this time were fresh and recently emerged, but a few were quite worn, and had evidently been flying for a week or two. In the same locality on August 13, however, the center of distribution had moved upward, so that the species was common in the higher Hudsonian and Arctic Alpine tundra and meadows. Of 8 females taken at this locality in both July and August, 3 are light yellow, and 5 are white.

Scudderi is definitely a butterfly of the Upper Canadian and Hudsonian Zones, although during the first part of the season many specimens will be found in middle Canadian Zone. It thus contrasts strongly with *alexandra* which is practically always found in the same general localities but which is essentially of the lower and middle Canadian Zone.

I have no records of *scudderi* from north of the Snowy Range in Wyoming, west of the Uinta Mts. in Utah, or south of the Sangre de Cristo Range in northern New Mexico. Further collecting is desirable, to determine whether it occurs in any other parts of the West. *Scudderi* has always been considered as limited to Colorado, so that its presence in the Uintas is rather surprising, and holds forth the possibility that it may occur in the Wasatch Range and even reach southeastern Idaho; I strongly doubt this latter, however. The arid country of the Red Desert and southwestern Wyoming seems to be a dividing line between

northern and Colorado forms in a great many cases, and will probably prove so in this one.

Colias scudderi ruckesi, new geographic subspecies

A large series of *C. scudderi* taken in Windsor Canyon in both 1935 and 1936 shows sufficient differences from *C. s. scudderi* to warrant the description of a new geographic subspecies based on this material. I name this *ruckesi* in honor of my companion in 1935, Dr. Herbert Ruckes. From *s. scudderi, ruckesi* differs chiefly in the following characteristics:

(1) In *ruckesi* the black marginal border of the upper side of the wings of males is proportionately wider than in *s. scudderi.*

ruckesi, 45 ♂ ♂	
Average length of fore wing	22.68 mm.
Average width of border in cell M_1 of fore wing	5.786 mm.
Border-width percentage of wing-length	25.51%
scudderi, 52 ♂ ♂	
Average length of fore wing	22.860 mm.
Average width of border in cell M_1 of fore wing	4.984 mm.
Border-width percentage of wing-length	21.80%

(2) In *ruckesi* the black discocellular spot of the upper side of the fore wings of males is more often reduced in size, or absent, than in *s. scudderi.*

ruckesi, 45 ♂ ♂	
Spot present, large	2 = 4.44%
Spot present, small	11 = 24.44%
Spot present as a trace	10 = 22.22%
Spot absent	22 = 48.88%
scudderi, 52 ♂ ♂	
Spot present, large	9 = 17.3%
Spot present, small	16 = 30.7%
Spot present as a trace	20 = 38.4%
Spot absent	7 = 13.4%

(3) The ground color of fresh specimens of *ruckesi* is a brighter, more intense yellow than that of *s. scudderi.*

(4) The black basal dusting on the upper side of the wings is somewhat heavier and more wide spread in *ruckesi* than in *s. scudderi.*

Holotype male, allotype female, nineteen male and one female paratypes, from Windsor Creek Canyon, west of Cowles, N. Mex., July 2, 1935, collected by the author. Twenty-five male and nine

female paratypes from the same locality, July 4, 1936, collected by L. E. Chadwick, Richard Whitmer and the author. All were taken in about middle Canadian Zone, at from 9000 to 9500 ft. altitude, in grassy meadows surrounded by forest, along the Forest Service trail about halfway between Cowles and the summit of Santa Fe Baldy Peak.

Holotype, allotype, six male and two female paratypes deposited in the American Museum of Natural History; four male paratypes deposited in the U. S. National Museum; four male paratypes deposited in the Canadian National collection; the remainder of the paratypes at present in the author's collection.

Although *ruckesi* is not an extremely well-marked race, I am convinced that it is worth naming. It is not to be expected that in such a race as this every specimen will be distinct from any specimen of another race; and such is the case here. In the type series of *ruckesi* are at least eight specimens which from appearance might well be *scudderi;* and I have one specimen of *s. scudderi* from Twin Lakes, Lake Co., Colo., that in appearance is a perfectly typical *ruckesi.* A series of *ruckesi* has, however, a very distinctive appearance, and is separable at a glance from a series of *s. scudderi.* In fact, with its wide, dark borders and its reduced discocellular spots, such a series is at first glance very strikingly suggestive of *C. palaeno.*

The race *ruckesi* may be taken as representing the southern part of the population of *scudderi.* I doubt that *scudderi* will be found to occur south of the Sangre de Cristo range; but if it should be taken in the Mogollon, Sierra Blanco-Sacramento or Sandia-Manzano Ranges, the more southern specimens may well prove even more different from *s. scudderi* than the type series described above.

Only eleven females were taken, a number insufficient to warrant any generalizations regarding the characteristics of this sex of *ruckesi.* Of these 5 are bright yellow, 2 are yellowish-white, and 4 are white. Of 37 females of *s. scudderi* from Colorado, Utah (Uinta Mts.) and southern Wyoming which I have studied, only 7 are definitely yellow; so this color in a larger proportion of the females may be a characteristic of *ruckesi.*

One of the females taken in 1936, when confined in a jar with samples of most of the potential food-plants of the region, laid

several eggs on willow and ignored everything else. Unfortunately the larvæ emerged in Arizona, and all succumbed to the heat of the desert, which was very understandable at the time.

Colias pelidne skinneri Barnes

Two males and a white female of this interesting form were taken at Middle Piney Lake on Aug. 10 and 11, flying along a steep, unforested hillside; one male and the female were visiting a species of *Polygonum,* and the other male was on a large, orange *Helianthus* in company with other butterflies.

It is probable that the Wyoming and Salt River Ranges mark the southern limit of distribution of *pelidne,* although there is a possibility that it may occur in the Wasatch or Uinta Mts. It almost certainly does not occur in the Colorado and contiguous ranges.

Brenthis aphirape Huebner

A series of *B. aphirape alticola* B. & McD. was taken at the type locality for this subspecies, Hall Valley, on July 15. Almost all were flying in a grass-sphagnum bog at about 11,000 ft. alt., near the upper limit of timber but in upper Canadian Zone. Only one specimen was taken outside of the limits of the bog, and that one was visiting flowers on a contiguous slope. Previous collecting in other parts of the valley had failed to reveal any specimens, but the reason for this was made evident when the rather restricted habitat of the species was discovered. All the specimens were freshly emerged.

One just-emerging, crippled male was taken in a Hudsonian Zone, grass-willow bog between Class Lake (now, in 1936, known as Lewis Lake) and the base of Medicine Bow Peak, in the Snowy Range, Wyo., on July 22, and three more specimens were taken in the same place on August 13; of these latter three, two females were quite fresh and the third, a male, was rather worn. Intensive collecting in neighboring meadows and tundra, carpeted with flowers and swarming with *Brenthis helena,* failed to reveal any more specimens; so that it seems as if here, too, *aphirape* is restricted to a bog environment.

The considerable series of topotypical *alticola* from Hall Valley as well as a number of other specimens from other Colorado

localities which I owe to the kindness of Messrs. F. M. Brown and L. E. Chadwick, enable me to here characterize *alticola* somewhat more fully than was done in the original description, especially with regard to *B. a. dawsoni* B. & McD., geographically the nearest of the other *aphirape* subspecies.

Upper side. The ground color is a lighter, more yellowish brown, the black transverse markings are narower and more clean-cut, and the black basal dusting is less evident; there is less evidence of the presence of a hazy, zigzag, fuscous line basad of the submarginal row of round, black spots on the primaries, and distad of the outermost, zigzag, black line.

Under side. The ground color is a slightly lighter tan, but not appreciably different from that of *a. dawsoni* and *a. triclaris.*

Under side of secondaries. The dark bands (postbasal, median and submarginal) are a much lighter, orange-brown than in *dawsoni,* in which these bands, especially the postbasal and median, are darker, ranging from a dark orange-brown to a very dark reddish-brown. The submarginal dark band (immediately basad of the marginal row of triangular spots) is invariably interrupted sharply in cells M_2 and M_3, while in *dawsoni* and *triclaris* this band is often complete. The median dark band is clear-cut, while in *dowsoni* and *triclaris* its edges, especially the outer edge, are very diffuse. The postbasal dark band is much narrower than in *dawsoni* and *triclaris;* this is especially noticeable in the spot of this band located in the discal cell, which is invariably narrower than the light spot immediately basad of it; in *dawsoni* and *triclaris* the band-spot in the cell is usually wider than the basal light spot.

The above-mentioned spot in the cell of the dark basal band may contain a light spot, but in *alticola* this is usually not the case. Of 18 specimens of *alticola* this spot is present, large and ocellate in 1, is present as a mere whitish trace in 3, and is absent in 14; of 64 specimens of *dawsoni* and *triclaris* the spot is large in 43, is present as a trace in 17, and is absent in 4.

The light, basal and submedian bands of spots are of a clear yellowish color, with a faint trace of silver in only 2 out of 18 specimens. In all 18 specimens of *alticola* the spots of the marginal row are slightly iridescent silvery, except in two in which they are strongly silvery. In *dawsoni* and *triclaris* the silvery iridescence is strongly marked in the majority of specimens in all the spots of the three bands.

In most of the above characteristics *alticola* is much more different from Manitoba (including Churchill), Alberta and Saskatchewan *dawsoni* than it is from truly Arctic specimens (mostly good *triclaris*) from Alaska and Labrador; in fact, a number of specimens from these latter regions are very close to *alticola,* and would excite no comment if taken in Colorado.

A resemblance of this kind led Leussler (Bull. Brooklyn Ent. Soc. 1935, **30**: 52) to record *alticola* from the Mackenzie delta at the same time that he referred to other Arctic specimens as *dawsoni*. Such a procedure is based on an erroneous concept of the principles of subspecific taxonomy. The name "*alticola*" does not apply to *any* specimen with the *alticola* characteristics, no matter where found; it should be used solely to refer to the *population* of specimens of the species *aphirape* that occupy that *area* where *alticola* characteristics are predominant, even though occasional specimens from that area may not (phenotypically at least) possess these characteristics. Individuals from a thousand or two miles away from Colorado are a part of a population from a different area, and therefore, in this case, a part of a different subspecies. A most interesting case of this kind is described below under *B. h. helena*.

As noted above only four specimens of *aphirape* were taken in the Snowy Range, and this hardly constitutes a sufficiently large series on which to base any conclusions. It is worth recording, however, that all of these specimens are in color and pattern much closer to *dawsoni* than to *alticola*, which is far from what one would expect. Study of the distribution of *Colias* and *Brenthis* in the Rocky Mountain region shows that in the majority of cases the "break" between a Canadian race and a southern mountain race seems to come either in Montana or at the great ecological barrier of the Red Desert in Wyoming and the Great Basin lowland country in northern Utah. There is no apparent topographical, climatic, or other environmental barrier between the Snowy Range and the mountains of central Colorado where typical *alticola* occurs; so that the occurrence of *dawsoni* in the Snowy Range and of *alticola* in the contiguous ranges southward would be most surprising. Very probably more complete collecting will solve the problem.

Brenthis myrina tollandensis B. & McD.

One specimen only, a freshly emerged female, was taken; this was in a grassy marsh about three-quarters of a mile below the University of Wyoming camp, in the Snowy Range, on July 20. This agrees with the writer's previous experiences with this spe-

cies in the Rocky Mountains; it is rather rare and of very local distribution, occurring only in marshy places. It seems to emerge later in the season than the other, more typically Western species of *Brenthis*.

Brenthis kriemhild Strecker

Only one specimen of *B. kriemhild* was taken in 1935, a very badly worn female; it was in a lower Canadian Zone meadow at Green River Lake, August 5. In my experience *kriemhild* emerges somewhat earlier in the season than other species of *Brenthis* found in the same localities. It appears to be typically a lower to middle Canadian Zone species.

Records from eastern Utah and western Colorado are needed to fix the southeastern limits of the range of this species. At Payson, Utah, it is common, but I know of no more eastern records than this; it is very possible, however, that it occurs on the western slope in Colorado.

Brenthis helena Edwards

B. helena Edw. was taken at all suitable localities where collecting was done.

At Cowles, N. M., on July 2 two very fresh males were taken in a small meadow in Windsor Canyon, at about the upper middle of the Canadian Zone forest belt; this constitutes the southernmost record for the occurrence of this species of which I am aware. It also represents the lowest life-zone record I have for *helena helena,* which may be due to the fact that it was very early in the season and that the species was just beginning to emerge. One additional *Brenthis,* doubtless a *helena,* was seen on the same day in Hudsonian Zone on Santa Fe Baldy Peak at about 12,000 ft. alt. These New Mexico specimens do not appear to differ in any important respect from Colorado specimens, except that they seem brighter red beneath.

The species was found common at Hall Valley on July 15; this was in swamp and swampy meadow in upper Canadian and lower Hudsonian zones, at about 11,000 ft. alt. Many were flying and visiting flowers in company with *B. aphirape alticola.*

A considerable series of freshly emerged males, but no females, was taken in the Snowy Range from July 15 to July 23, and rep-

resented the earliest emergents of the species for the season in this locality. All were in Hudsonian Zone grassy meadows above the upper limit of the forest. On August 13 the locality was revisited, and a large series was taken, the species being found in abundance in the same environment. A number of specimens were also taken higher up on the slope of the mountains in upper Hudsonian Zone; but even at this late date no specimens at all were seen in Canadian Zone meadows, although a few hundred feet up the mountains the species was common. It is interesting to note that whereas in July only males were taken, in August the sexes were present in nearly equal numbers.

A series of *helena* was taken at Mummy Pass on August 19 and 21; all were found in Hudsonian and Arctic-Alpine zone meadows and tundra only.

A number of the specimens collected in the Snowy Range are rather peculiar and extremely interesting, for they show distinct resemblance to *B. chariclea chariclea* and *B. chariclea arctica*. On the underside of the secondaries the marginal row of spots, and the spots of the submedian light band immediately above, at the end of and below the discal cell are silvered; the remainder of the spots of the submedian band tend to be obliterated by the ground color; the spot at the end of the cell is greatly elongated and pointed; and the ground color is a rich, reddish brown with purplish shades. One of the specimens is so nearly perfect a match for a specimen of *chariclea arctica* from White Strait, Baffin Land, that either might well be mistaken for the other if the data labels were ignored.

I have long considered that *chariclea* is the closest relative of *helena* and probably represents somewhat of an ancestral form. This being so, the circumpolar *c. chariclea* and *c. arctica* might well be expected to show greater resemblance to *helena* than the more southern *c. grandis* or *c. boisduvalii*. At the close of the last glaciation, *chariclea* probably spread rapidly southward in North America, with the result that for a time all of the suitable parts of the continent would be occupied by a comparatively homogeneous population. Then as time went on, and the climate became milder, barriers would arise and isolation factors come into play; the homogeneous population would be split into a num-

ber of more or less separated populations, although these need not be actually different from each other; and opportunity for subspeciation and speciation would come. The final result, the production of such variant strains as *montinus* in New Hampshire, *boisduvalii* in Labrador and the subarctic regions, *grandis* in southern Canada, *rainieri* in Washington, *ingens* in Idaho, Montana and Wyoming, and *helena* in Colorado, Utah and New Mexico, is thus easily understandable, and presents a simple and plausible explanation of the presence of these more or less interrelated "races."

In such a case none of these forms just mentioned need be considered as ancestral to any of the others; all may be considered as divergent to a greater or lesser degree from a common, ancestral *c. chariclea-c. arctica* stock. Furthermore we must not assume that the mere accident of geographic contiguity will produce the same or close evolutionary results; for in so doing we would ignore many possibilities of divergence through the appearance of mutants. And this being so there is nothing surprising in the fact that the southernmost member of this complex, *helena,* should show a greater resemblance to the northernmost, *arctica,* than do the intermediate ones, *grandis, rainieri* and *boisduvalii;* or that in a population of *helena* there should occasionally arise by fortuitous combination an "atavistic" individual such as the one described above.

The same phenomenon of close similarity of a southern and an arctic race has been noted before in this paper in the case of *B. aphirape,* races *triclaris* and *alticola.* It is possible that the same explanation may apply there.

Brenthis helena ingens B. & McD.

A considerable series of *helena* taken in northwestern Wyoming (vic. Green River Lake, July 24–Aug. 7 and Middle Piney Lake and Wyoming Peak, August 9–12) may be referred to the race *ingens* B. & McD., described from the Yellowstone Park, although these specimens are not as entirely typical of this race as specimens from further north. The average length of fore-wing in a series of 34 males of *h. helena* from Colorado was found to be 18.95 mm, as contrasted with an average length of 21.08 mm in a

series of 21 males from the Wind River and Wyoming Ranges, which would place the latter series in *ingens* on size alone. In other characters they also agree with *ingens* rather than with *h. helena.*

Ingens appears to be a valid race of *helena,* though not an extremely distinct one; the characters cited in the original description all seem to hold true in series.

Judging from the material I have studied, *helena* does not intergrade to *chariclea* its nearest relative, through *ingens,* as might be expected from topographic data; instead there appears to be a closer resemblance between *h. helena* from Colorado and Utah and *c. rainieri* from Washington than between the geographically more contiguous *h. ingens* of Montana and *c. grandis* of Alberta. Study of more material from Montana, Idaho and southern Alberta may, of course, demonstrate the reverse to be true.

Brenthis freija Thunberg

Specimens of *freija* were taken at Hall Valley July 14–15, and in the Snowy Range July 17–23. In all cases they were in extreme upper Canadian and Hudsonian Zones, flying in grassy bogs and meadows. With the exception of one female from the Snowy Range all were rather badly worn, which bears out a previous conclusion of mine that *freija* is the earliest species of Rocky Mountain *Brenthis* to be on the wing. On June 8, 1933, a specimen of *freija* was taken by me on Pikes Peak, in middle Canadian Zone meadow, at 8700 ft. altitude, when no other butterflies were yet flying. This record is, incidentally, of additional interest, as being the only case known to me of a *freija* occurring below the uppermost Canadian Zone.

Dark specimens of *freija* are often erroneously identified as *tarquinius* Curtis, probably largely because of unfamiliarity with the true *tarquinius.* Study of series from Greenland and Baffinland shows that this name should be restricted to specimens from such extreme Arctic regions as these, where the population is predominantly large in size, with very heavy fuscous and chocolate-brown markings and suffusions. I have never seen a southern specimen of *freija,* even in a large series from Churchill, Manitoba, which was not easily distinguishable from the true *tar-*

quinius; although doubtless very rare accidents do occur. A considerable series from interior Alaska which I have examined are all to be classed as *freija* rather than as *tarquinius*. *Natazhati* Gibson, also from Alaska, is of course distinct, but is to be considered as a race of *freija* rather than as a distinct species as is sometimes done.

Brenthis epithore Edwards

The eastward limits of the range of this species are unknown to me. Holland records the species in the "Butterfly Book" from "as far East as Colorado," but inasmuch as he considered *sagata* Barnes and Benjamin to be conspecific with *epithore,* this is not to be taken too seriously. I have one specimen from an unknown, old collection labelled "Steamboat Landing, Colorado," but the data on this may be erroneous. It is certain that if it does occur in the Great Basin and Rocky Mountain regions, *epithore* must be very rare east of the Sierras.

Brenthis frigga Thunberg

The southern distribution of *B. frigga saga* Stdgr., and all the limits of distribution of *B. frigga sagata* Barnes & Benjamin are not known, and I would very much appreciate any information on the subject. In the Butterfly Book (rev. ed., p. 111) Holland errs in placing *sagata* as a synonym of *epithore.* I have seen the types and other Colorado specimens of *sagata,* and do not hesitate to state that it is unquestionably a valid, small-sized race of *frigga,* and as such is perfectly distinct from any other species of *Brenthis.*

Intensive collecting at the type locality, Hall Valley, failed to produce any specimens of *sagata* in 1935, although we were there at the right time. Possibly it occurs in some very limited environment, which we missed.

Bugs, Birds and Blizzards in the Yellowstone. By Harlow B. Mills. Collegiate Press, Inc., Ames, Iowa, 1937. 9 × 6 in., vii + 76 p., stiff paper covers, wire binding, $0.50.

This is an interesting account of the things to be seen in Yellowstone Park, which are not seen at all by the average visitor. It was written by a naturalist, of which there are so few real ones these days. Rocks, rivers, insects, birds, beasts, trees, sunsets, people, food, warmth, shelter, and everything that enters a complete life in the open, impinged themselves upon the consciousness of Dr. Mills, and with his appreciation of the background that lies behind seemingly simple things, he has woven them into a fascinating and intensely personal narrative which all good naturalists will enjoy reading. I would rather sit at home and read this account than go to Yellowstone Park and see only "Old Faithful and a mangy bear."—H. B. W.

The Sacred Bee in ancient times and folklore. By Hilda M. Ransome. 8.5 × 5.5 inches, 308 p., 12 pl., 35 figs. Boston and New York, Houghton Mifflin Company, 1937. $3.50.

This book is packed from cover to cover with interesting and fascinating information about bees and beekeeping from early times down to about the middle of the nineteenth century. The author traces the history of beekeeping through Ancient Egypt, Babylonia, Assyria, India, China, Greece, Italy, and various countries of Europe and writes in some detail of the use of bees and honey in connection with the religious, domestic, mythological and artistic life of the various inhabitants. Myths, folklore, customs, legends and superstitions, all connected with bees, crowd the pages of this book, together with illustrations as interesting as the text. And there is even a chapter about the bee in America, devoted chiefly to practices by the Maya.

There is no doubt about this book finding its way into all the entomological libraries of the country. And there are thousands of beekeepers, who, theoretically, should each own a copy, but I fear that the practical beekeepers as a group are no more interested in the historical and cultural sides of beekeeping than peanut vendors are interested in the history of peanuts.—H. B. W.

THE NORTH AMERICAN SPECIES OF NEMADUS THOM., WITH DESCRIPTIONS OF NEW SPECIES (COLEOPTERA, SILPHIDÆ)*

BY H. C. FALL
TYNGSBORO, MASS.

The genus *Nemadus*, erected in 1859 by C. G. Thomson for a small number of species of the silphid tribe Catopini, seems not to have been looked upon with favor by his contemporaries, nor was it accepted by Horn in his Synopsis of the North American Silphidæ in 1880. Horn was familiar with Thomson's work and in general regarded it highly, but evidently did not consider the characters on which *Nemadus* was founded as of more than group value within the genus *Ptomaphagus*. *Nemadus* however is given generic recognition in late European Check Lists and is used by Dr. H. M. Hatch in his recent paper—"Studies on the Leptodiridæ (Catopidæ)," (Journ. N. Y. Ent. Soc., Mar.–Jun., 1933). In this paper, *parasitus* Lec., *pusio* Lec., and *horni* Hatch n. sp. (previously confused with *pusio*) are referred to *Nemadus*, based on the following characters.

> Pronotum not transversely strigose; apex of hind tibia with rather long unequal spinules; basal joint of middle tarsus of male slightly dilated and spongy pubescent beneath.

Long before his death in 1912, my lamented friend Frederick Blanchard, of Tyngsboro, Mass., became greatly interested in the collection and study of his local species of *Ptomaphagus*. I quote the following from his note book under date May 27, 1894.

"Besides the very common *parasitus*, occurring abundantly with a black ant (*Formica subsericea* Say) under stones, and the

* A short time before the present paper was prepared and submitted for publication, there appeared in the Memoirs du Museum National D'Histoire Natural (Paris, 1936), a Monograph of the Catopidæ by Dr. R. Jeannel. This work has only recently come to my attention and I have not as yet been able to determine whether any synonymy is involved.

very rare *brachyderus* which lives with *Camponotus pictus* in pine logs and stumps, there are three other species which seem to be more or less common.

"1. With *Formica exsectoides,* the mound building ant, there is a rather large species at once known by the obliquely narrowed elytra and the more slender antennal club. 2. With *Formica integra,* an ant much like *exsectoides* but rather more robust, not mound building, discharging a tiny stream of formic acid when disturbed, occurs a *Ptomaphagus* with sides of elytra broadly rounded as in *parasitus.* This species is larger than *parasitus,* with a broader thorax, the disk similarly clouded, both sexes shining. 3. With *Camponotus pictus* and *C. pennsylvanicus* occurs a species rather larger and broader than *parasitus,* easily known by the prothorax always without fuscous cloud, the strigæ of the elytra finer and closer, pubescence thin and fine, male shining, general color more castaneous or reddish brown than in *parasitus.*"

These three species all agree with *parasitus* in those characters which indicate the genus *Nemadus,* and in my opinion all are valid species. Examples of all these were included in a large lot of more than one hundred specimens sent by Mr. C. A. Frost to Dr. Hatch, who however failed to differentiate them from *parasitus.*

The following tabular synopsis is offered for the separation of the six species here recognized. The descriptions of the new species are quite brief, embodying little more than those characters which are of diagnostic value.

Types of the new species are in the writer's collection. Paratypes of all are in the Blanchard collection.

TABLE OF SPECIES

1. Elytra broadly rounded on the sides, at most only moderately attenuate posteriorly; pronotum more or less clouded with fuscous (except *pusio*) 2

   Elytra strongly attenuate, the sides less arcuate 5

2. Form rather narrow and more evenly oval, widest at about the middle of the length; average size somewhat smaller; eighth antennal joint less than half as long as the ninth and at least twice as wide as long 3

   Form a little broader and more ovate, the point of maximum width a little before the middle of the length, the elytra moderately attenuate

though with rounded sides; eighth antennal joint much less disk like, always less than twice as wide as long, and usually nearly or quite one-half the length of the ninth joint 4

3. Both sexes with alutaceous sculpture between the elytral strigæ; elytral strigæ less oblique, nearly transverse. California; British Columbia . . . . . *pusio* Lec.

Male without, female with alutaceous sculpture between the elytral strigæ (Mass. to Mich., Colo. and Fla.) *horni* Hatch

4. Elytra shining in the male, alutaceous and duller in the female; size smaller but averaging a little larger than in the two preceding species . . . . . *parasitus* Lec.

Elytra in both sexes shining and without alutaceous sculpture; size distinctly larger . . . . *integer* n. sp.

5. Antennal club very slender, joints 7, 9 and 10 conspicuously longer than wide; pronotum always more or less clouded with fuscous. *gracilicornis* n. sp.

Antennal club less slender, joints 7 and 9 little if any longer than wide, 10 as wide or wider than long; pronotum never with dorsal cloud . . . *obliquus* n. sp.

Nemadus pusio Lec.

Of this small species I have seen only the type in the Le Conte collection. It is a female, 1.6 mm. in length, reddish brown in color the head darker, outer four joints of antennal club piceous, the terminal joint paler at tip. It was taken at Point Reyes, on the coast a short distance north of San Francisco, California. Other recorded localities range from Los Gatos in the Santa Cruz Mts. south of San Francisco (Hatch) to Vancouver, B. C. (Horn). It is our only known Pacific Coast species.

Nemadus horni Hatch

This name is given by Hatch to the specimens occurring in the Eastern States, which hitherto have been referred to *pusio*. These differ from *pusio* in having the pronotum more or less piceous, the elytral strigæ slightly more oblique, and with alutaceous sculpture between the strigæ only in the female. In the twenty-three examples which I have examined the antennæ are sometimes unicolorous but more often with darker club, in which case the terminal joint is more or less pale. In length they scarcely vary from 1.75 or 1.85 mm. Hatch gives 2.2 mm. as the upper limit, which is so extraordinary as to suggest the possibility of error. This species is widely dispersed, ranging from

New England to Alabama and west to the Mississippi River. The type locality is Framingham, Mass.

Nemadus parasitus Lec.

The type of this common species is a male, 1.9 mm. long, from "N. Y." The LeConte series contains three other N. Y. specimens, two from "D. C." and two without locality labels. The average size is perceptibly greater than in the two preceding species but rather less than in the three which follow. The color varies from a yellowish brown to castaneous, the pronotum more or less clouded with fuscous. The form is a trifle broader than in *pusio* and *horni,* the elytra are broadly arcuate on the sides and only moderately attenuate.

In his remarks under this species Hatch says that it closely resembles *Dissochaetus brachyderus* Lec. This is equivalent to saying that the elytra are strongly attenuate behind, which is never the case in the true *parasitus,* and shows conclusively that the author confused therewith two of the species which follow, viz. *gracilicornis* n. sp. and *obliquus* n. sp.

Parasitus is more widely dispersed than any other of our species, occurring, if the records can be trusted, from Quebec to Manitoba and Colorado and south to Virginia and Texas.

Nemadus integer new species

Strikingly similar to *parasitus* but generally of larger size, as is quite evident when series are compared. The color is reddish brown, the disk of the pronotum with fuscous area of variable extent; antennal club not infuscate, 8th joint about one-half the length of the 9th and much less than twice as wide as long. Elytra broadly rounded on the side and only moderately attenuate posteriorly, as in *parasitus;* surface polished and without micro-sculpture between the strigæ in either sex. Length 2.1 to 2.25 mm.

More than thirty examples have been examined, mostly in the Blanchard collection. The type is a female bearing label "Lowell Ms." but was undoubtedly taken in Tyngsboro, as were all the Blanchard specimens; a single female from Framingham, Mass., is in my collection.

The absence of alutaceous sculpture between the strigæ of the elytra in both sexes is the most important diagnostic character of this species as is indicated in the preliminary remarks.

Blanchard's specimens were always taken with a different ant from that with which *parasitus* occurred.

Nemadus gracilicornis new species

Broader anteriorly than in *parasitus,* the elytra more strongly attenuate, the size distinctly larger. The color is reddish brown, the head piceous, the pronotal disk more or less broadly infuscate, antennal club not darker. The antennal club is more slender than usual, joints 7, 9 and 10 conspicuously elongate, these being at most but slightly longer than wide in *parasitus;* 8th joint about half the length of the 9th and scarcely one-half wider than long. Elytra widest near the base, the sides thence but little arcuate and strongly converging to apex; interstrigal surface smooth or very nearly so in the male, distinctly minutely alutaceous and less shining in the female. Length 2.1 to 2.3 mm.

Some forty specimens of this species have been examined. They bear labels—Massachusetts (Tyngsboro; Framingham; Natick); Connecticut (Cornwall); New Jersey (Ramsey); Manitoba (Aweme). The type is a male from Cornwall, Conn. (K. C. Chamberlain) and bears date "23, IV, 1922."

The more slender antennal club, fuscous pronotal area, and subtriangular elytra form a combination of characters which distinguish this species from all others in the genus. The elytra are nearly as strongly attenuate as in *brachyderus* but lack the lateral subapical sinuation present in that species.

Nemadus obliquus new species

Broadly ovate, the sides of the elytra strongly convergent from near the base. Color uniformly reddish brown or castaneous, the pronotum never with any trace of discal cloud. Antennæ concolorous, 7th and 9th joints varying from nearly as long to slightly longer than wide, 8th about half the length of the 9th but a little variable, 10th rarely if ever as long as wide. Elytra strongly wedge shaped, about one-third longer than wide, sides very broadly arcuate; surface shining in the male, the interstrigæ not or scarcely visibly alutaceous, perceptibly alutaceous and duller in the female. Length 2.0 to 2.25 mm.

The size is a little larger than in *parasitus* but somewhat smaller than in *integer* or *gracilicornis,* and is proportionately broader than in either of them. The absence of pronotal cloud at once separates this species from all other normally colored eastern members of the genus, and the strongly cuneiform elytra distinguish it from all but *gracilicornis,* in which the antennal club is a little more slender with the 10th joint always longer than wide.

I have studied or passed in review more than forty specimens of this species, the larger number being in the Blanchard collection. The type is a female taken by myself at Tyngsboro, Massachusetts, VI–2–1925. Other localities represented are Dracut and Framingham, Mass.; Newark and Montclair, New Jersey; and Philadelphia, Pa. (Liebeck Coll.).

THE USE OF HONEY BEES FOR TESTING LIQUID INSECTICIDES*

BY FRANKLIN C. NELSON
STANCO, INCORPORATED

During the month of August, 1925, the writer was called upon to find an insect which would be suitable for testing liquid insecticides and at the same time be readily available throughout the year. A number of insects were tried out but most all of them were unsatisfactory for various reasons. House flies (*Musca domestica*) and biting stable flies (*Muscina stabulans*) were reared and gave satisfactory results in the tests but due to a lack of space and poor heating conditions, it was impossible to carry them through the winter.

It was finally decided that honey bees (*Apis mellifera*) were the most readily available and possessed a degree of sensitivity that should lend itself readily in the detecting of differences in concentration of a nerve poison such as pyrethrum. A hive of bees was therefore brought into the laboratory for preliminary test work. Small screen wire "Hodge type" fly cages were purchased for the handling of the bees during treatment. These were 5″ in diameter across the bottom and about 4″ high at the peak of the cone top. They consisted of two separate parts, as shown in figure 1.

In the center of the bottom or inner cone of the cage, a small hole was made just large enough to allow the bees to enter. All cages were waxed with hot paraffin before use as it was found that the bees died in a few hours without any spray treatment at all if placed in cages not so waxed. Just why this occurred was not determined but they were seen to bite on the iron wire quite viciously and they must have gotten something from the wire to cause their death. The waxed cages seemed to prevent most of

* The work reported in this paper was done as a part of a project administered by the Crop Protection Institute, financed by Stanco, Incorporated, and carried out in cooperation with the Department of Entomology of Rutgers University.

this chewing. Using honey as a food, caged bees in waxed cages lived for several days. The waxing was done by heating the paraffin until liquefied, then the cages were dipped in the hot wax and immediately blown with air to remove the excess wax from the wire openings, leaving a thin coating on the wire. All cages were burned and rewaxed after each test in order to remove any liquid spray remaining on the cage.

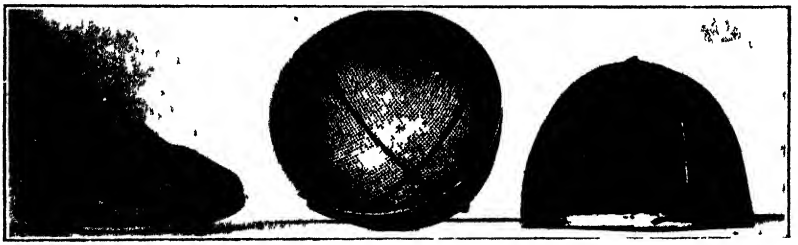


FIG. 1

HANDLING THE BEES

When the hive of bees was brought into the laboratory, it was placed by a window and a runway was fixed in the entrance, which allowed the bees free access to the out-of-doors on warm days in winter, as well as during the summer. A tight inner cover was nailed on the top of the hive before it was brought in and the center hole of this cover was fitted with a sliding door and cone wire runway which extended upward about 4″. The wire cages were placed on this runway and the cover opened to allow the bees to run into the cage. The bees in a new, well-stocked hive rushed out freely and found their way almost at once into the cage above. After about ten bees had entered the cage, it was quickly removed and an empty one put in its place. This was readily done without allowing any bees to escape, if care and speed were used in the transfer. This procedure was continued until enough cages were filled to run a complete test. The number of cages depended, of course, on the number of samples to be tested. As each cage was filled, a daub of honey was placed on the top of the cage for food and a small cork was fitted into the entrance hole to prevent the bees from escaping. When the bees refused to run out of the hive readily, the hive was jarred sharply

or a long wire was run in from the top in order to stir them up and cause them to run out. After the hive was somewhat depleted, it then became necessary to remove the inner cover and pick the bees out with a small forceps, placing them one by one in the wire cages. This was done without harming the bees by picking them up by the legs and quickly placing them in the cage. If there was any fear of being stung while handling them, the operator wore a bee veil and long canvas bee gloves. Any one at all familiar with bee habits should have no difficulty in the handling of them for this work. After enough cages were ready they were lined up on a testing table or rack within easy reach of the operator. The most convenient grouping was found to be several shelves one above the other so arranged that a single row of cages, set out on each shelf, facilitated both spraying and later readings.

SPRAYING EQUIPMENT

The delivery of the spray material was controlled in every way possible in order to eliminate variations due to equipment. An air compressor and reserve tank were used with an automatic control to maintain fairly uniform pressure. Oil and water separators were also used to keep the air dry and the sprayer from clogging. An air control valve of the Hoke type was set at three pounds' pressure for the proper maintenance of the air pressure. The atomizer used was the Weber Indestructible #2. These were rebuilt to suit the particular need for this job by closing up the liquid tube in the top and redrilling a smaller hole. These atomizers were extremely simple and were adaptable for downward spraying. No doubt other suitable sprayers may now be found that will direct the spray downward but at the time this method was devised there seemed to be nothing more suitable at a low price.

The spraying apparatus consisted of the following: a small square box 4½″ high and 9″ square which formed a base for the glass cylinder. The corners of this box were open to allow free passage of air and spray particles. This was fastened securely by screws to one corner of a table. On the top of this box was nailed a round cover 12″ in diameter by ⅝″ thick with a hole in

the center approximately 4¾" in diameter and just large enough to hold the bee cage when turned upside down in the spraying position without allowing it to fall through. On top of this cover was placed a pyrex glass cylinder open on both ends and 12" high and 9½" in diameter. This was held in place by nails on four sides of the cylinder. The use of this round glass cylinder prevented air currents from blowing the fine spray particles away from the cage. On one side of this arrangement an iron ring stand was fastened to the table to form a support for the sprayer. This stand was 36" high with a ⅝" upright rod. A clamp and extension arm was fastened to this 2" above the top of the glass cylinder and directly over the cage and in this clamp was fastened the small atomizer previously described. All of this equipment was fastened securely to prevent it from shifting during the spraying process. This equipment is shown in figure 2, and 2A. 2A is just a close-up view of the actual spraying equipment which does not show plainly in figure 2.

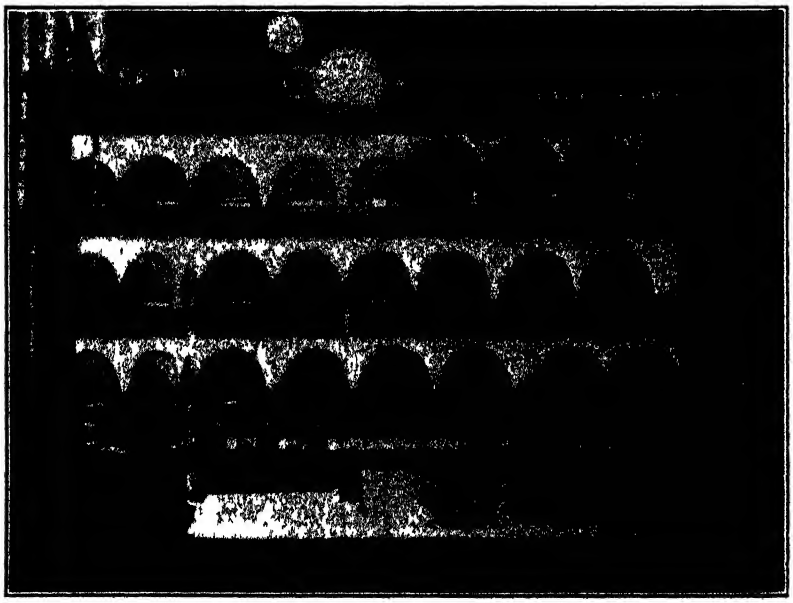


FIG. 2

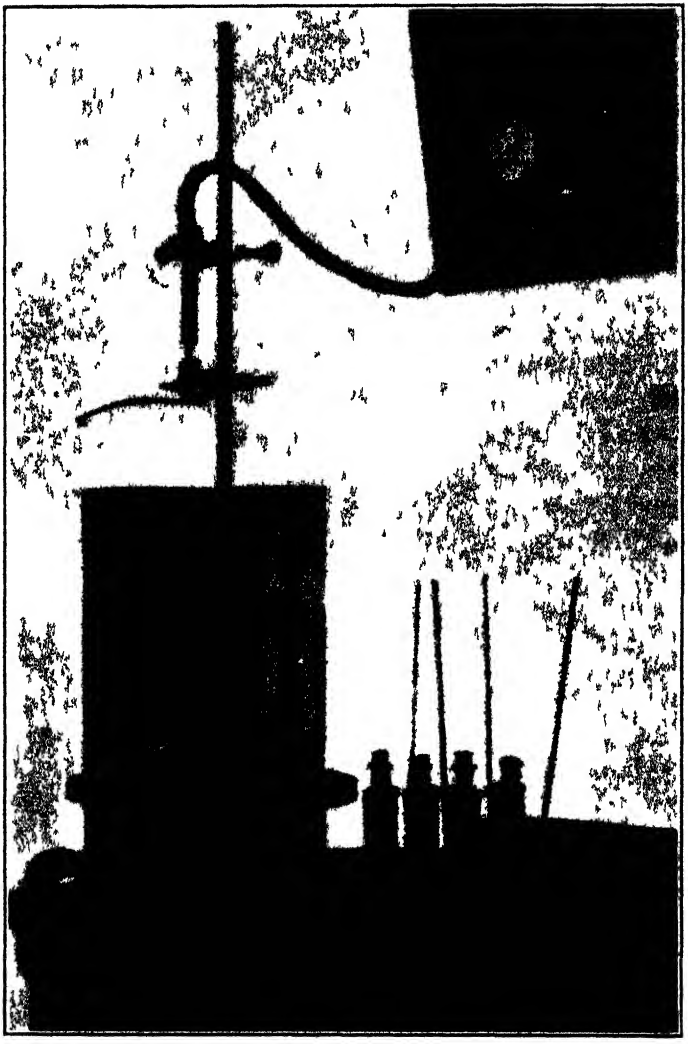


FIG 2A

In centering the sprayer so that the spray was directed at the exact center of the cage, pieces of white blotting paper were used and colored liquid sprayed on them until the exact center was located. The sprayer was then locked in position and rechecked

for centering. Small round-bottom vials were used to measure out the liquid to be sprayed. They were first carefully calibrated by means of an accurate pipette and each dosage was clearly marked on the side of the vial for later measurements. These were only used where one or two dosages were needed for each sample. In other tests requiring more accurate results and where more dosages were used, small pipettes were used for all measurements. In any case, an individual vial or pipette was used for each sample to eliminate the necessity of cleaning such measuring vials between sprayings. A rack was made to hold the sample bottles and vials in order to prevent the vials from getting mixed up with the wrong samples and to prevent spilling. This is shown in figure 2.

SPRAYING PROCEDURE

Several variations in procedure have been used from time to time depending upon results desired but only two types of methods will be described at this time. For ordinary quick indications not demanding too accurate results, only one dosage was used per sample and a total of 400 bees or 40 cages per sample. In this test 0.8 cc. of Flit was found to give close to the 50 per cent. kill figure and was used as a standard dosage. Each sample was alternated and a cage sprayed every minute, for example, sample #1 at 8 o'clock, #2 at 8:01, #1 at 8:02, #2 at 8:03, etc., until 80 cages were sprayed. Readings were also taken at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, as well as 24 hours. The 30-minute reading was not always taken, but was used mainly on very strong samples. This meant that after 30 cages were sprayed a reading and a spraying had to be done every minute until the cages were all sprayed. This could readily be done with a little experience. It might have been unnecessary to make five observations but the writer felt that a more accurate picture could be drawn from several readings rather than from only one or two. These individual time readings were then averaged for the entire test and graphs were drawn up to show just what the test indicated. The details of this will not be gone into at this time as they are more carefully considered later.

The second, and more accurate method employed, required the use of several dosages per sample and, using an insecticide such

as Flit, the dosages that worked out most satisfactorily were 0.1 cc., 0.3 cc., 0.5 cc., 0.7 cc., and 0.9 cc. per cage. Observations were again made at 30 min., 1 hour, 2 hours, 4 hours, 6 hours and 24 hours. Pipettes of 1 cc. capacity were used for measuring these dosages as the volume of liquid was much too small to allow ordinary measuring in a tube. The measured liquid was placed in the smallest vial available that would work satisfactorily on the atomizer. The dosages and samples were alternated in regular rotation, for example, 0.1 cc of #1, 0.1 cc. of #2, etc., and then 0.3 cc. of #1, 0.3 cc. of #2, until all the dosages were completed for the series. They were then repeated in the same rotation until the entire test was finished. In this test, 480 bees were required per dosage or a total of 2,400 bees per sample. This represented a large amount of work but the results obtained could be depended upon without the question of doubt that might arise in a test less complete.

The amount of time necessary to complete a test of this type was longer than desirable for conditions that called for large numbers of tests, but if accuracy rather than speed was desired, the method was found to be very satisfactory, especially for research samples. A great deal of the time in this test was taken up by filling the cages with bees, getting equipment ready from day to day such as burning off the wax and other details involved in the test. With, for example, two samples to be run, an operator sprayed 60 to 80 cages per day and as these carried over for the 24-hour reading, it was necessary to supply at least 160 cages for one tester. The time necessary to complete this test ran from 6 to 8 days, depending on the speed and experience of the operator. If he could spray more than 80 cages per day, it, of course, required less time to complete the test. Aside from the speed of the operator, the number of cages sprayed per day depended on the ease and speed with which the bees could be caged, as well as the speed in burning and rewaxing cages. Readings were recorded day by day on specially printed record sheets as shown in figure 3.

The 30-minute period is not shown as it was not always used and was written in when desired. Only the heading "Dead" was used on these records to facilitate the reading. After all

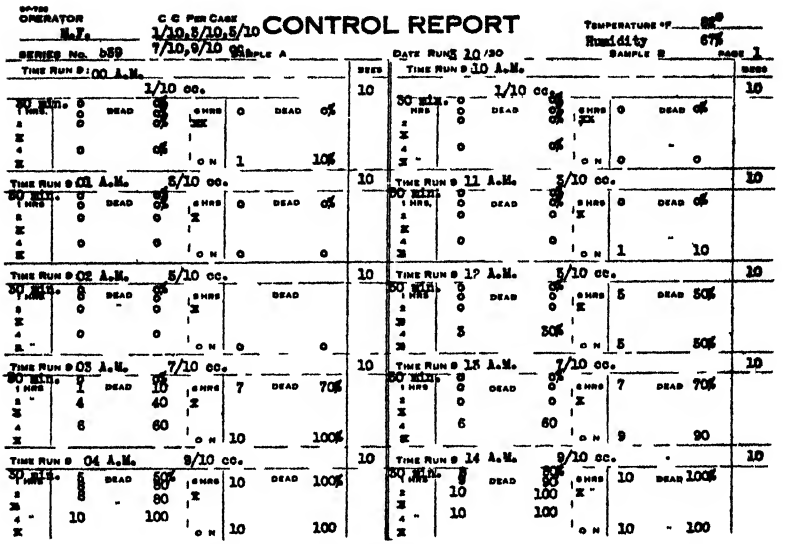


FIG. 3

the tests were completed, the results were tabulated under each dosage and at each reading period. For example, with the 0.1 cc. dosage the results were tabulated for the 30-minute reading, then the hour, two hour, etc. The same procedure was carried out with 0.3 cc. dosage and all the others. Each of these sets of readings was then averaged and this average was used as one point for establishing a representative graph for each dilution. Some of these results are shown in the set of figures that follow for one dilution which was taken from an actual test set to show just what was done. Graph No. 1 following this record sheet is based on the same test and represents a complete set of five sheets for each sample similar to the one shown here and covers all dosages involved.

The following graph is based on the above summary of per cent dead for each dosage and time reading and gives a very clear picture of results that may be expected from the same insecticide at varying concentrations as well as the comparative picture between two different insecticides.

SAMPLE SHEET SHOWING ALL READINGS ON INDIVIDUAL CAGES OF SAMPLE A. SIMILAR SHEETS ARE MADE FOR THE OTHER DILUTIONS OF SAMPLE A AND ALSO FOR SAMPLE B

Dead

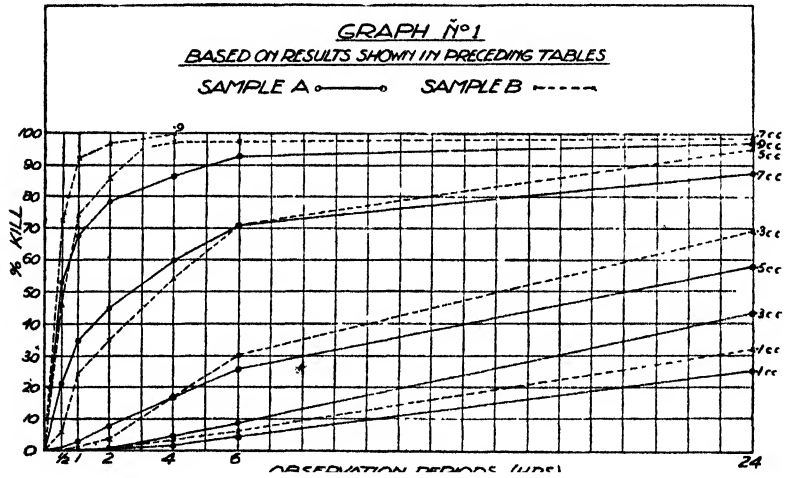
cc. Used	30 Min.	1 Hour	2 Hours	4 Hours	6 Hours	24 Hours	Total bees per cage
	0	0	0	0	0	5	10
	0	0	0	0	0	5	10
	0	0	0	0	0	4	10
	0	0	0	0	0	4	10
	0	0	1	1	1	1	10
	0	0	0	0	0	2	10
	0	0	0	0	0	0	10
	0	0	0	0	3	0	10
	0	0	0	0	1	6	9
	0	0	0	1	1	7	10
	0	0	0	0	5	1	10
	0	0	0	1	0	6	10
1/10	0	0	0	0	0	4	10
cc.	0	0	0	0	0	4	10
per	0	0	0	0	0	4	10
cage	0	0	0	0	0	4	10
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	0	0	0	2	10
	0	0	0	0	2	5	10
	0	0	0	0	2	6	10
	0	0	0	0	2	6	10
	0	0	0	0	1	5	10
	0	0	0	0	0	4	10
	0	0	0	0	0	0	10
	0	0	0	0	0	0	8
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	1	1	1	1	10
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	0	0	0	0	10
	0	0	0	0	0	2	10
	0	0	0	0	0	2	10
	0	0	0	0	0	7	10
	0	0	0	0	0	4	10
	0	0	0	0	0	0	10
	0	0	0	0	0	1	10
	0	0	0	0	1	2	10
	0	0	0	0	0	0	10
	0	0	0	0	0	1	10
	0	0	0	0	0	0	10
	0	0	0	0	0	0	11
	0	0	0	0	0	0	9
	0	0	0	0	0	2	10
	0	0	0	0	0	4	11
	0	0	0	0	0	4	10
	0	0	0	0	0	0	10
No. Dead	0	0	2	4	20	118	478
Per cent Dead	0	0	0	1	4	25	

Summary of per cent dead of all dosages for Sample A

cc. Used	30 Min.	1 Hour	2 Hours	4 Hours	6 Hours	24 Hours
1/10 cc.	0	0	0	1	4	25
3/10 cc.	0	0	0	4	8	43
5/10 cc.	1	3	8	17	26	58
7/10 cc.	21	35	45	60	71	88
9/10 cc.	53	68	79	87	93	98

Summary of per cent dead of all dosages for Sample B

1/10 cc.	0	0	0	3	6	32
3/10 cc.	0	1	4	17	30	69
5/10 cc.	7	24	35	54	71	96
7/10 cc.	48	74	87	96	98	99
9/10 cc.	73	92	98	100	100	100



DISCUSSION

I have attempted in the preceding figures and description to give an accurate working picture of the method of using honey bees for laboratory testing work. In reviewing the preceding graph, it is evident at once why a low or a high concentration with a resulting low or high kill is unsuitable for comparative testing work. If one looks at the 1/10 cc. dosage, for instance, he will see that the difference between these two samples is well within experimental error both as the 24-hour reading and at all the other periods of observation. The 3/10 cc. dosage comes

somewhat nearer to being a satisfactory concentration in that it falls above and below the 50 per cent. point. It does not, however, show the wide-spread difference between the two samples that the middle dosage or 5/10 cc. does.

The 7/10 cc. and 9/10 cc. results taper off after reaching a fairly high toxicity in six hours and again these would be unsuitable for comparison work by themselves as the difference between the samples with these concentrations narrows down to experimental variation at the 24-hour reading. By using a series of concentrations such as shown here, it is possible, however, to obtain a very clear picture of what is happening and if by any chance the insecticides should be very poor or unusually strong, at least one or two of the concentrations would fall in the optimum point of comparison and the test would therefore be acceptable.

The speed of paralysis is, of course, not shown at all but one can obtain a fair picture of speed of kill, which is also valuable and would probably, to some extent, fall in line with a similar paralysis figure. An additional observation might be added to the method to determine speed of paralysis based on time elapsed between spraying and the point when all bees were on the bottom of the cage.

All of this, of course, takes a great amount of time both in the actual spraying operations as well as in the calculations of results but when a sample is completed there is little room for doubt as to exactly what may be expected. It is because of this accuracy that we have felt justified in using a complicated test of this sort.

It will probably be of value to point out at this time some of the advantages and disadvantages of the method.

ADVANTAGES

1. A steady supply of insects may be readily obtained throughout the winter months without the necessity of setting up a breeding laboratory. All insects are also of the same sex and about the same age, during winter months at least.

2. The insects are large, comparatively easy to handle and are very sensitive to most nerve poisons.

3. This method does not require the setting up of expensive testing rooms or other expensive testing apparatus.

4. It is a direct spray method and with the dosages divided up into such small amounts and sprayed on the bees directly, the chances of each bee receiving uniform amounts of liquid are probably better than in a "chamber" method.

5. The results obtained with this method have been shown to be very satisfactory for comparing intrinsic toxicity of two samples even though it is not a method that is directly comparable to field conditions.

6. The method can be readily adapted to testing emulsions simply by changing the liquid tip in the atomizer and spraying larger volumes of spray liquid. It can also be adapted to dusting tests although it is not, of course, quite as accurate as with liquids.

DISADVANTAGES

1. The method requires considerable time to complete a single test.

2. A great many people object to handling honey bees because of the danger of stinging.

3. Speed of paralysis cannot be as accurately determined as in a "chamber" test.

4. Honey bees are not household insects and the results obtained cannot be taken as an interpretation of actual field results. This is particularly true in regard to recovery. Honey bees that have been affected by a spray seldom ever completely recover, although they do live beyond the 24-hour period. With flies, the recovery is often high and such flies seem to return to complete normalcy in spite of the treatment. Honey bees also do not respond to the action of various types of hydrocarbons to the same relative extent as do flies and cockroaches, and for this reason the relative killing power of two insecticides may be somewhat different if determined by the bee method than if tested against flies.

In spite of the limitations shown above and even though this method has been almost entirely replaced in our own laboratories by other methods involving the use of some of the so-called "household insects," the writer feels that it has considerable merit as a laboratory test method and is worthy of presentation.

JOURNAL OF NORTH-AMERICAN MOSS-MITES

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Because of the rapid development of the study of the superfamily Oribatoidea, and the cost of figures, it has become necessary to name and describe some of these species in much more condensed form than has been my ideal. I have on file, however, a set of detailed sketches of these species, and will retain the types until opportunity presents itself to complete the descriptions. Lots, the numbers of which bear a capital F, are to be deposited at the National Museum, otherwise at the Museum of Comparative Zoölogy.

After a careful study of certain genera which include a holarctic species, I find that in holarctic species the notogastral bristles tend to occupy the same relative positions in each of the subspecies while subspecific differences occur in the modification of chitinous ridges or expanses, that is, the position of the bristles is more stable than the development of the chitinous ridges and spurs. Examples are *Tectocepheus velatus* and *Oppia corrugata* (see below).

Trhypochthonius silvestris sp. nov.

Differs from *T. americanus* (11) in that the pseudostigmatic organ head and the notogastral bristles are pointed, not blunt; and that bristles a1 are minute and simple; other bristles of notogastral disc short but barbed or bristled.

COTYPES: Thirty specimens from litter of isolated short-leaf pine stand two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F15.2.

Nothrus silvestris (22, p. 458, Pl. 7, Figs. 4)

The following American specimens are identical with those from Regensburg: One specimen from cushion moss, upland swamp, East Village, Monroe, Conn.; taken March 23, 1919, slide 1913n4. Two specimens from grey-green moss on rock, upland

swamp woods, East Village; taken August 25, 1925, slide 2531n1. Six specimens from hemlock leaf mould, hill above state road, gorge, Sandy Hook, Conn.; taken June 24, 1926, slide 2613n1.

Nothrus terminalis carolinae subsp. nov.

DIAGNOSTIC CHARACTERS: Differs from the species (2, p. 10, Pl. 1, Fig. 8) from Austin, Texas, in having abdomen more sharply rounded behind; bristles e3 more distant from f2; rostral bristles short, pointed; lamellar bristles much larger, clavate.

DESCRIPTION: Abdomen with deep, narrow, dorsal groove distant from edge about twice its width, four bristles along lateral edge, the second (b3) inserted on transverse plane slightly anterior to c1, the third (d3) inserted on transverse plane slightly posteriad of d1; e1 as approximate as a1, subequally distant from d1 as d1 is from c1, directed mesad and usually crossing near distal end; e2 between e1 and f2 but nearer f2; the humeral bristle is a3; a2 shorter than the others; altogether there are 13 bristles visible in dorsal aspect and two in ventral aspect (inserted on edge of notogaster), all these bristles as well as lamellar and interlamellar are smooth edged but have a couple of fine longitudinal lines; pseudostigmatic organs closely barbed.

COTYPES: Thirteen and fifteen specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slides 34F11C1 and -C2.

Nothrus monodactylus comb. nov.

Nothrus anauniensis monodactylus (8, p. 381) from Columbia, Mo., is closely related to the above, possibly synonymous. It cannot be redetermined until material from the type locality and type habitat is studied.

Camisia spinifer (Koch)

Specimens from the Asheville basin (N. C.) are identical with specimens from Regensburg. They differ from the figures of Michael (21, vol. 2, Pl. 48, Figs. 7–13) in that the rostral bristles have very short apophyses, the apophyses of the lamellar bristles are as long as the body of the large posterior apophyses, and that the posterior pair of mesal bristles (that is bristles a5) are lacking. Although Michael shows a bristle laterad of the second mesal pair (a2), I believe these to be the distal ends of b1 recurved to that position. Neither Nicolet (22) or Willmann (29, p. 110, Fig. 62) show such and none such occur in Regensburg specimens. Finally the specimens from western North Carolina have much longer bristles than figured by European Acarologists

and they are very irregularly roughened by barbules, thorns and minute apophyses (in caustic-potash cleaned specimens). These asperities may be identical with what Michael calls "villous processes."

If Michael's figures are accurate the English Islands may be endowed with a distinct, insular subspecies. Fortunately the continent of North America (at least in the east) will not force a trinomial on our already burdensome nomenclature. *Pseudotritia ardua* and *Northus silvestris* are the only other species known to me to lack subspecific differentiation from the European.

Camisia spinifer, in life, is very grimy, the dorsal bristles being so intersmeared as to give the dorsum the appearance of a rectangular basket, the bristles being the withes from which the basket is woven. My wife and I always refer to it as "The Basket Nothrus."

Genus BELBA (14a, p. 611)

Resembling Damaeus but with tectopedia II not developed laterad of insertion of legs I, thus without auricles between legs I and II.

TYPE: *Notaspis corynopus* (14, p. 89, Pl. 4, Fig. 2).

Belba olitor sp. nov.

Body pulverulent; legs moniliform; cephaloprothorax nearly as wide as abdomen; pseudostigmatic organs very long, flagelliform; lamellar bristles similar to rostral, inserted just above them; exopseudostigmal bristles and interlamellar bristles fairly long, flagelliform, the latter inserted quite close to pseudostigmata; posterior edge of cephaloprothorax with cornicles; notogaster semiglobular, with eighteen rather stout, black, slightly curved bristles forming a crescent of nine bristles on each side, the anterior pair inserted rather close together, the fifth pair inserted on longitudinal plane passing slightly mesad of the fourth and sixth, the ninth pair much more slender, elongate, flagelliform, on posterior margin two additional pairs of slender flagelliform bristles, subequally spaced laterad of ninth pair, spines (of anterior edge) long, curved, slender; genital and anal apertures subequal, separated by a narrow arm of ventral plate; tibia, genual, and femora IV each with a fairly long flagelliform bristle.

COTYPES: Eight specimens from twenty-year old-field of Andropogon and twelve-year-old pines, Cook property, Avers Creek Township, Buncombe Co., N. C.; taken February 19, 1935, slide 34F25.2–4.

This species is usually found with nymphal notogasters piled on its back. These skins are net-reticulate and have longer bristles than the adults.

Gymnodamaeus quadricaudiculus sp. nov.

Resembles *G. austriacus* (30, p. 334, Figs. 17–19) in the caudal appendage of the notogaster but in the American species the notogaster terminates in four, small, circular nubbins each bearing a stout, curved bristle; pseudostigmatic organs slenderly clavate, fairly long, the head studded with a plush of spikes; notogaster sculptured with an oval ridge from which there radiates six spurs or rays, one extending anteriad, one posteriad, and two laterad (each side); dimensions: length of body 0.4 mm.; breadth of notogaster 0.23 mm., length of notogaster 0.28 mm.

COTYPES: Fifty to sixty specimens from Andropogon sod, Glen Bald, Bent Creek Experimental Forest, Buncombe Co., N. C.; taken April 17, 1925, slides 34F31n1 to -n3.

Genus **Oppiella** gen. nov.

CHARACTERS: Differs from Oppia in that the notogaster is moderately arched, often with anterior band more or less raised as a ridge, bearing eighteen bristles, often with an additional pair on anterior peripheral band; sides of thorax above legs II and III usually smooth or with a few low ridges, cephaloprothorax often with conspicuous knobs or/and ridges; tectopedia II variously developed.

TYPE: *Dameosoma corrugatum* (5, p. 273; 24, p. 62, Pl. 4, Fig. 23).

In a recent paper (19) I recorded the type of Oppia as having pseudostigmata distant from anterior edge of notogaster. Since having written this statement I have secured specimens of *Oppia nitens* from the type locality and type habitat; under bushes in gardens, Regensburg, and find that the pseudostigmata are close to the anterior edge of the notogaster. Thus Dameosoma is a synonym of Oppia. *Dameosoma ultraciliata* (19, p. 19, Figs. 16–22) and *D. alces* (19, p. 23, Figs. 154–158) thus become *Oppia ultraciliata* comb. nov. and *Oppia alces* comb. nov. respectively. In the same paper *Phauloppia bryani* should be *Eporibatula bryani* comb. nov.

Oppiella corrugata comb. nov.

This species has recently been referred to as *Oppia neerlandica* (29, p. 128, Fig. 132). I am unable to see any relation between Oudemans' figure of his

Eremæus neerlandicus (23, p. 168, Fig. 4) and that by Paoli (24, Pl. 4, Fig. 23) and by Warburton and Pearce (28, p. 567, Pl. 20, Fig. 2). especially as I have found Oudemans' figures to be quite accurate. This species is represented in the eastern United States by the following forms:

Oppiella corrugata apicalis subsp. nov.

(Figures 3–7)

As the species but sides of ridge along anterior edge of notogaster more nearly parallel and the bristle inserted at posterior bend of the ridge (Figure 3). For contrast I have included a figure of this area from specimens coming from Regensburg (Figure 1). The position of the other notogastral bristles is identical with the Regensburg specimens. They are figured as quite differently situated by Paoli for Berlese's Florentine types. Moreover, the anterolateral projection of the notogaster (shoulder spur) is longer, more extended while it is short and blunt in Regensburg specimens. Size: large for the genus, but quite variable.

COTYPES: Thirty-one specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F120p3.

Nine specimens from Great Falls, Va.; taken May 19, 1914, by Nathan Banks, slides 26B104 and -b, are intermediate between this and the next form.

Oppiella corrugata squarrosa subsp. nov.

(Figure 2)

As the species but sides of ridge along anterior edge of notogaster quite parallel, forming a right angle at both anterior and posterior ends though the bristle is inserted anteriad of the posterior bend of the ridge (figure 2); other notogastral bristles as in the above; shoulder spur pointed, much as figured by Paoli for the Italian race (24, Pl. 4, Fig. 23); lamellæ often with strongly developed, fine, slender, cross-ridges; lamellar bristles (in heavily sclerotized individuals) inserted on a disclike expansion of distal end of lamellæ.

MATERIAL EXAMINED: Three specimens from decaying vegetation scraped from north side of *Carex stricta* tussock, upland swamp, East Village, Monroe, Conn.; taken August 7, 1925, slide 2513n1. Five specimens from dead, overhanging leaves, east side of tussock, same locality; taken August 10, 1925, slide 2514n3. One hundred five specimens from clump of sphagnum near above tussocks; taken August 18, 1925, slides 2520n2, 2521n7, -n8, -n9, 2522n5. The sample was sun dried, beginning

at 9 A. M. The container was emptied at 11:30, 4, and 6 P. M. yielding 5, 77 and 23 specimens respectively. One specimen from core cut from top of a *C. stricta* tussock, same locality; taken August 22, 1925, slide 2525n1. Nineteen specimens from decaying vegetation scraped from sides of a *C. stricta* tussock from open marsh (recently cut over), stream valley, northeast of East Village; taken August 28, 1925, slide 2533n2. Three specimens from old, decaying, wet grass from foot of old haystack on hillside, beyond above marsh; taken September 1, 1925, slide 2534n1. Sixty-two specimens from dead leaves in woods, edge of above upland swamp; taken September 9, 1925, slide 2538n1. Eight specimens from hemlock leaf mould, from hill above state road, gorge, Sandy Hook, Conn.; taken June 24, 1926, slide 2913n1. Six specimens from moss on and scrapings from old log, and leaf mould, below state road, gorge, Sandy Hook, Conn.; taken June 25, 1926, slide 2614n1. Fifteen specimens from leaf mould, old hemlock grove (with Polytrichum, Carpinus, and Fagus), west slope of Miamus Ravine, N. Y.-Conn.; taken in April, slides 26n1 and -h1.

One specimen from decaying leaves at base of clump of marsh sedge, Cliff Island, Casco Bay, Me.; taken September 14, 1925, slide 2539n3. Twenty-one specimens from sphagnum of cranberry bog, same locality; taken September 17, 1925, slides 2543n1, -n6, 2544n1, -n2, -n3. These specimens from the Maine coast have the ridge of anterior edge of notogaster less square than in Connecticut specimens but the shoulder spur is well developed.

One specimen from under a stone, South Salem, Ohio; taken May 1, 1924, (no. 212 and 213), slide 32M102 (Miller coll.).

HABITAT: Quite ubiquitous on decaying vegetation. Although not recovered from several moss samples, it seems to be common in sphagnum! This is the commonest species of the genus with general distribution, that is it has the highest frequency.

Oppiella foliosa sp. nov.

(Figures 9–12)

DIAGNOSTIC CHARACTERS: **Bristles short, broad, clavate, blunt (figures 9 and 12); cephaloprothorax with raised ridges, simulating lamellæ and translamella, and others; notogaster with a pair of shoulder spurs and their**

bristle; pseudostigmatic organ head stout, directed mesad; posterior end of abdomen strongly tapering.

DESCRIPTION: Size medium; total length 0.23 mm., breadth 0.115 mm.; color reddish brown; rostrum broad, with a pair of minute apicules each side of median plane; rostral bristles bent toward each other (figure 9); posterior edge of cephaloprothorax more densely sclerotized to base of pseudostigmata, sides of cephaloprothorax with a more densely sclerotized ridge running from base of pseudostigmata forward to transverse plane of apodemata I, narrowing and turning mesad (figure 9); lamellar and translamellar bands distinct on lateral and anterior edges only; a broad, distinct band (each side) passing from lateral ends of translamellar band anteriad nearly to insertions of rostral bristles; lamellar bristles inserted posteriad of base of these translamellorostral bands; interlamellar bristles inserted on transverse plane passing anteriad of anterior edge of pseudostigmata, on a very slender ridge which runs from slightly anteriad of insertion to posterior band; pseudostigmata distant from notogaster; pseudostigmatic organ pedicel strongly bent, head broad, either studded with short, close-set bristles clotted with foreign matter or having that appearance (figures 10); apodemata III broad, very conspicuous.

Notogaster broadly ovate, anterior end pointed; posterior end somewhat mammilate, sculptured with what has the appearance of fine, pale, irregularly longitudinal lines (figure 9, anterior area); bearing the usual eighteen bristles but in regular transverse rows (which I take to represent the primitive condition); the bristles are quite flat (figure 9, bristles d2), and somewhat veined (figure 12), except the posterior pair e1 which seem more clavate and shorter; spur bristles stout, pointed, barbed (figure 11). The spur bristle, which probably represents the true a1 or a2, is often of a different form than the other notogastral bristles.

Anal aperture close to posterior edge of plate; covers with bristles close to median edge; postanal bristles behind center of cover; pseudofissuræ well developed, lateral postanal bristles foliose, inserted anterolaterad of pseudofissura, preanal bristles slender, far anteriad of anal aperture, thus in this genus these last two bristles have migrated anteriad while in the pterogasterine genera they have migrated posteriad. Due to this great diversity in position my nomenclature becomes ambiguous and I will hereafter use that of Grandjean (13, p. 57) which is:

paramesal	ag1 (agenital)
preanal or paranal	ad1 (adanal)
lateral postanal	ad2
mesal postanal	ad3

This system has the additional advantage of being more concise, and there seems to be no question about the identity of these bristles throughout the Oribatidæ or of their homology.

Genital aperture small, anterior edge strongly angled; the four cover bristles widely segregated in two pairs; parasterna III–IV with two foliose

bristles, the lateral of III (on a more densely sclerotized band) and the mesal of IV inserted on its usual spur; sternum broad between apodemata I and camerostome, narrow posteriad (figure 9); parasterna I with lateral bristle foliose; apodemata I short.

HABITAT: Soil samples, Asheville basin.

COTYPES: Thirteen specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F13a0p3.

Oppiella stipularis sp. nov.

(Figures 13 and 14)

DIAGNOSTIC CHARACTERS: Bristles somewhat broad, tapering to a point, that is, resembling slender stipules (figure 13); cephaloprothorax with ridges as in *O. foliosa* but without translamellorostral pair; notogaster suboval; shoulder spur bristle minute; pseudostigmatic organ head pointed, bristled in two rows (figures 13 and 14).

DESCRIPTION: Size medium, total length 0.246 mm., breadth 0.115 mm.; color pale; shape slender; closely related to *O. foliosa* but a linear as to shape of body and bristles; rostrum broad; posterior band of cephaloprothorax not developed; lamellæ and translamellæ more definite; lateral bands more lateral (figure 13); pseudostigmata closer to notogaster; interlamellar bristle ridge extending further forward; lamellar bristles inserted on end of lamellæ.

Notogaster more elongate, anterior end truncate; bristles with a raised median ridge (figure 13, bristles d2), arranged in more strongly curved rows; a pseudofissura anterior to bristles b2 quite distinct, long; anal aperture extending laterad nearly to edge of ventral plate; anal pseudofissuræ shorter, at center of sides of aperture; bristles ad3 close to posterior edge of ventral plate, ad1 near edge of ventral plate; genital cover bristles 2 nearly posterior to bristles 1; sternum not as broad as in *O. foliosa;* apodemata I longer.

COTYPES: Three specimens from epigeous moss between Andropogon stools; closely browsed Andropogon pasture between wooded ridges, two miles southwest of Bent Creek on Asheville-Brevard road; slide 34F130p1.

It is not at present possible to state if this is a moss or a soil species.

Genus SUCTOBELBA (24, p. 72)

Oppias with mouth parts attenuated; mandibular chelae fine and slender; edge of camerostome variously modified but chiefly developed ventrad and divided by one or more incisions to form lobes or lacinia; lamellar bristles springing from a prominently

raised knob just anterior to plane of pseudostigmata; this lamellar knob appears triangular in dorsal aspect.

TYPE: *Suctobelba trigona* (Michael) Paoli (24, p. 74, Pl. 4, Fig. 31; Pl. 5, Fig. 50).

Several closely related American species may be segregated in the following genus:

Genus **Suctobelbella** gen. nov.

Suctobelbas with two pairs of spurs projecting from anterior edge of notogaster out over base of cephaloprothorax; anterior edge of notogaster between mesal spurs indistinct; rostral bristles usually ciliate-pectinate; notogastral bristles eighteen; bristles ag1 much nearer edge of ventral plate than to median plane; acetabulæ III projecting laterad of notogaster as an oblong lobe bearing a small colorless nubbin on anterior face.

Type: *Suctobelbella serratirostrum* sp. nov.

A study of the various locations of the notogastral bristles leads me to the conclusion that, at least in this genus, it is the five anterior bristles which are most restless. Referring to bristles of figure 8 as the typical, primitive condition, and disregarding the spur bristle (which may be a1 or a2), I regard the anteromesal pair of bristles as a1, the bristle posterolaterad of a1 as a2, the bristle posterior to a1 as b1, and that posterior to b1 as b2 which has shifted into the mesal series from its lateral position. In the genus Suctobelbella, bristles c2 are actively in the process of making this same change of position as will be noticed in the case of the following five species.

Suctobelbella serratirostrum sp. nov.

(Figures 16 to 20)

DIAGNOSTIC CHARACTERS: Edge of camerostome cut by two (or three) incisions to form two or three lacinia (figure 17), pseudostigmatic organs clavate, bent, head ovate, distally attenuate, directed anteromesad, smooth, or with a few minute bristles, or the bristles irregularly arranged three or four abreast across the head, thus forming a brushlike structure (figures 16 and 20); notogastral bristles fairly long, fine, overlapping, a2 much closer to a1 than to b1, c2 only slightly more remote than b1, or b2, which are nearly in the same longitudinal plane (figure 16); ad2 on transverse plane passing through or slightly posteriad of anterior edge of anal aperture.

DESCRIPTION: Size medium (for the genus): length 0.2 to 0.21 mm., breadth 0.1 to 0.11 mm.; rostrum broad, not sharply demarked; rostral bristles standing out laterad as a grand moustachio; lacinia plainly visible in dorsal aspect

(figure 16), for shape of this area in anterodorsal aspect see figure 19; in posteroventral or anterodorsal aspects the lacinia seem to converge (figure 18); dorsal face of cephaloprothorax with the usual median, scallop-edged band and lateral bands enclosing a thinner area (figure 16); interpseudostigmatal ridges resembling an old English letter i, the interlamellar bristle inserted on the anterior end; behind the pseudostigmata a more densely sclerotized ridge with a posterior lobe passing under the shoulder spur.

Notogaster broadly oval, posterior edge cut away (lower half of figure 16); spurs subequal; bristles a1 more remote than lateral spurs! Posterior edge of anal aperture strongly angled; sides strongly converging (anteriad); anterior pair of cover bristles much more remote than posterior pair; bristles ad3 slightly more remote than breadth of anal aperture, nearly on same transverse plane as posterior cover bristles (figure 16); ad2 midway between edge of ventral plate and anal aperture; anterior edge of genital aperture gently curved; cover bristles 2 and 3 not very distant, the four bristles forming a very gentle curve; sternum anterior to genital aperture quite broad; apodemata II–III interrupted.

The smaller individuals have fewer bristles on the pseudostigmatic organ head. The appearance of the edge of the camerostome varies much according to angle at which it is seen.

COTYPES: One hundred and fifty-four specimens from Andropogon litter of a twenty year old-field grown to ten year old pines, Cook property, Avers Creek Township on Asheville-Brevard road, N. C.; taken February 25th, 1935, slides 34F25.3–5, –6 and –8. Large size from types.

Suctobelbella frothinghami sp. nov.

(Figures 23 to 25)

DIAGNOSTIC CHARACTERS: Rostrum extended anterolaterad as right angled corners (figure 23); this angle is formed by the centering of the distal end of the three lacinia of the edge of the camerostome at a common point; pseudostigmatic organ pedicel only slightly if at all bent below head, head oval to ovate, smooth, much shorter than pedicel (figures 23 and 24); notogastral bristles quite long (figure 23), bristles a2 on transverse plane passing nearer b1 than a1, c2 more remote than c1.

DESCRIPTION: Size large (for the genus, total length 0.246 mm., breadth 0.135 mm.; cephaloprothorax (figure 23) typical for the group except shape of rostrum; in lateral aspect (figure 25) edge of camerostome is seen to be produced ventrad as a point, above which are the reduced incisions, and fused lacinia, dorsoposteriad of which is a large thinly sclerotized reniform area; dorsal face of cephaloprothorax with the usual median, and lateral scallop-edged bands enclosing a thinner area (figure 23); pseudostigmata with a large posterior lobe which extends under the shoulder spur; interpseudostigmatic ridges bilobed, with well-developed connective which passes over

base of lamellar knob, interlamellar bristles inserted on anterior of the two lobes.

Notogaster, in dorsal aspect, nearly circular; median spurs broad, blunt; acetabulæ III very broad; notogastral bristles widely overlapping when depressed, bristles a1 posteriad of lateral spur, not distant from it, a2 nearer b1 than to a1, c2 more remote than a1, b1, or b2 which are in the same longitudinal plane (figure 23). Anal pseudofissuræ long; bristles ad2 inserted on transverse plane posterior to anterior edge of anal aperture, and near edge of ventral plate; genital covers with bristles 3 more remote than 2; parasterna III–IV with median bristle not as distant from the posterior bristle as greatest width of a genital cover.

HABITAT: Typically a species of deciduous woodland litter.

COTYPES: Thirty-seven specimens from litter of isolated shortleaf pine stand, two miles southwest of Bent Creek, on Asheville-Brevard road, N. C.; slide 34F10.20p1.

Named for Earl Hazeltine Frothingham, Senior Silviculturist at the Appalachian Forest Experiment Station.

Suctobelbella longicuspis sp. nov.

(Figures 21 and 22)

Similar to *S. frothinghami* but smaller (0.2 by 0.1 mm.); anterolateral corner of edge of camerostome drawn out into a fairly long lacinia, curved anteriad (figure 21), behind which are three subequal, much shorter lacinia, these lacinia separated by slender incisions, rounded at dorsal end, the proximal tooth merging into body of camerostome edge (figure 21); in dorsal aspect the long curved anterior lacinia is seen projecting each side of rostrum; pseudostigmatic organ head directed mesad, obliquely truncate (figure 22), side tapering proximad, not as elongately oval as in *S. frothinghami;* notogastral bristles a2 closer to a1 than to b1, bristles c2 slightly more remote than a1, b1, and b2.

Ventral aspect quite similar to *S. frothinghami.*

COTYPES: Twenty-four specimens with *S. frothinghami* but preferring the lowest part of the litter layer; slide 34F10.30p2.

Suctobelbella laxtoni sp. nov.

(Figures 28 to 30)

Color usually quite pale; size small, length 0.17 to 0.19 mm., breadth 0.09 to 0.1 mm.; abdomen high and broad; rostrum somewhat compressed so as to be narrower than anterior end of cephaloprothorax; edge of camerostome with three rather short and broad lacinia (figure 30); interpseudostigmatic ridges open mesad, forming a broad figure (figure 28); pseudostigmatic organ head compressed, dorsal edge with two or three rows of short, spiny

"bristles" (figures 28 and 29); notogastral bristles short, stout, stiff (not flexuous), a1 posteriad of mesal spur, a2 on transverse plane passing through b1 or only slightly anteriad, bristles c2 much more remote than b2; anal cover bristles both near lateral edge of cover.

HABITAT: Chiefly soil and lowest litter layer.

COTYPES: One hundred and seven specimens from Andropogon litter of a twenty year old-field grown to ten year old pines, Cook property, Avers Creek Township on Asheville-Brevard road, N. C.; taken February 25, 1935, slide 34F25.3–5, –6 and –8. The larger size is from the types.

Named for Miss Josephine Laxton of the Appalachian Forest Experiment Station.

Suctobelbella hurshi sp. nov.

(Figures 26 and 27)

DIAGNOSTIC CHARACTERS: Rostrum rounded, compressed, rostral bristles standing out at right angles; edge of camerostome with but one incision, thus forming only two rounded lobes (figure 27); pseudostigmatic organs quite similar to those of *Oppiella corrugata*, that is with fairly long cilia in one row, but with pedicel bent so as to direct head across prothorax; notogaster ovate, bristles medium long (figure 26), a1 more remote than lateral spurs, a2 on transverse plane passing near b1, c2 slightly more approximate than c1, thus having taken its place in the mesal row.

DESCRIPTION: Size medium, length 0.2 mm., breadth 0.1 mm.; cephalothorax quite typical; rostrum, in lateral aspect, low, with rounded dorsal outline; dorsal aspect of prothorax similar to that of *S.* (*S.*) *frothinghami* except that the interpseudostigmatic ridges are shaped roughly like a capital J without distinct crosspiece, the interlamellar bristle being inserted in the head (figure 26); notogastral spurs somewhat closer together; bristle a2 much nearer b1 than to a1 (figure 26); genital cover bristles 3 more approximate than 4. Easily recognized by the compression at base of rostrum and its peculiar shape.

HABITAT: Evidently a species of pasture sod.

COTYPES: Forty-two specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F120p4.

Named for Dr. Charles R. Hursh, Ecologist of the Appalachian Forest Experiment Station.

Eremulus cingulatus sp. nov.

Differs from *E. modestus* (6, p. 10; 7, Pl. 21, Fig. 79) in that the lamellar ridges are more remote, spanning the interlamellar bristles; there are no

pocks at base of cephaloprothorax; bristles a1, a2, b2 are well developed; the posterior edge of the post-thorax is indicated by a wavy line lined with areoles, the whole area being often raised (in lateral aspect) above the abdomen proper. Foreign matter coating the animal often hides this posterior edge of the post-thorax. Dimensions: length 0.36 mm.; breadth 0.19 mm.

COTYPES: Nine specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F11E.

Eremulus pectinatus sp. nov.

(Figure 8)

Differs from all described species by its strongly pectinate pseudostigmatic organs (figure 8). Dimensions: Length 0.25 mm., breadth 0.12 mm.

COTYPES: Fourteen specimens from surface soil and weeds of plowed land abandoned five years, Bent Creek area, ten miles southwest of Asheville, N. C.; slide 34F20.5.

Carabodes falcatus sp. nov.

(Figure 15)

Abdomen margined, shouldered, coarsely areolated, with translucent, clavate, appressed notogastral bristles; genital aperture distant from anal the length of genital; pseudostigmatic organs falcate, head pointed, linearly coarsely scabrate (figure 15); length 0.365 to 0.53 mm., breadth 0.2 to 0.3 mm.

COTYPES: Thirty-eight specimens from soil sample (including surface crumbles, that is the H layer) under eighty year old pine-oak woodland, Bent Creek Experimental Forest, Asheville basin, N. C.; slide 34F21.5.

Liacarus spiniger sp. nov.

Body oval, quite variable in size, length 0.49 to 0.68 mm., breadth 0.27 to 0.39 mm.; pseudostigmatic organs slenderly clavate, head subequal to pedicel, bearing a stout, burred spine nearly as long as head; distal end of lamellæ with corners drawn out as cats' ears, the mesal the longer; lamellar bristles stout, stiff, barbed, inserted on a slight swelling between the lamellar ears; interlamellar area produced as a cone; the two shoulder bristles shorter than spine of pseudostigmatic organs; notogastral bristles as long as diameter of tarsi and tibiæ I and II.

COTYPES: Twenty-nine specimens from same sample as the preceding; slide 34F21–27.

Closely related to *L. coracinus* (29, p. 152, fig. 214) but lamellæ with short blunt ears and shoulder bristles much longer.

Tectocepheus velatus 20, p. 189, Pl. 6

This species is represented by a subspecies in America. I say subspecies because the insertions of the rudimentary bristles are in the same position as in specimens from Regensburg (Bavaria).

In 1904 (4, p. 252) *T. minor* from Florence, Italy, was described as differing from the Italian *T. velatus* (3, fasc. 77/2) in having finer, more crowded granules, a less clavate pseudostigmatic organ and in being smaller (290 *versus* 350 microns long). The figures (9, Pl. 2, Fig. 31) show *T. minor* to have the same lamellæ as the Italian *T. velatus*. The pseudostigmatic organ head looks less clavate in some aspects or positions because the head is compressed not circular in cross-section. Furthermore this species is somewhat variable. Thus I do not regard *T. minor* as specifically distinct from *T. velatus*.

T. minor expansus (9, p. 422, Pl. 2, Fig. 32) is described as broader and shorter, cephaloprothorax longer and narrower, pseudostigmatic organs nearly twice as long, angle of pteromorphæ produced as a rounded angle, granules less dense than in the species. Type locality: North America. The figure (9, Pl. 2, Fig. 32) shows the distal ends of the lamellæ to be wider than in the species (*T. minor*) much resembling *T. v. sarekensis* (27, p. 517, Figs. 290–293). This Scandinavian form however has very different pteromorphae (27, Fig. 292). Thus the American form may be known as:

Tectocepheus velatus expansus comb. nov.

Differs from the species in having distal end of lamellæ broad, the bristle inserted on lateral edge; genital cover bristles 2, 3, and 4 (the three posterior bristles) subequally spaced while in Regensburg specimens bristles 3 and 4 are more widely spaced than 2 and 3. This is a normal condition, exceptions being present on both sides of the Atlantic.

In eastern America I find two marked forms which I will refer to as impressed and smooth. The impressed forms have a series of four fair sized impressions along each side of the notogaster. These are lacking in the smooth form. The impressions are plainly visible under magnification of twelve in dry material but

are invisible in mounted or alcoholic specimens. These two forms are further characterized by the following differences. The impressed have the pseudostigmatic organ head longer, more slender, the surface pebbled to nobby, the pedicel longer, sharply bent; notogastral bristles finer, pale, indistinct; notogastral pseudofissura distinct; surface without clean-cut granules but with flattened, smudgy, more widely spaced granules. This I take to be the true *T. v. expansus* because of the long pseudostigmatic organ and the more widely spaced granules. The unimpressed form has pseudostigmatic organ head shorter, broader, with surface strongly spiny, the pedicel shorter, nearly straight to gently curved; the notogastral bristles are larger, stouter, dark; the pseudofissura is indistinct; the surface has prominent, clean-cut granules.

These differences are not due to sex as individuals of both forms bear a maximum of two large eggs. Furthermore the two forms are not sharply segregated as to habitat, though one form or the other usually predominates. I therefore regard them as representing a dimorphic subspecies. I have not yet seen an American form with the pointed lamellæ of *T. velatus* as figured by Michael (21, p. 313, Pl. 21, Figs. 9–15). Specimens from one lot have two pairs of impressions on the anterior half of the notogaster, thus being quite intermediate in this characteristic.

Scheloribates muiricius sp. nov.

Similar to *Sch. lanceoliger* (6, p. 2) but pseudostigmatic organs resembling those of *Sch. muiri* (19, p. 53, pl. 8, figs. 69–79), adalar bristle close behind its porose area which is barred; posteriormost bristles of notogaster more remote, more remote than pair anterior to them, the porose area laterad; middle pair of sternal bristles at sides of slender sternum; length 0.4 to 0.44 mm.

COTYPES: Thirteen specimens from litter of isolated short-leaf pine stand, two miles southwest of Bent Creek, Asheville-Brevard road, N. C.; slide 34F10.2Sch.

This species is named after John Muir, seer of the Rockies. In general appearance, especially the pseudostigmatic organs, it resembles *Sch. muiri* which is named after the late Frederick Muir, formerly chief entomologist of the Experiment Station of the Hawaiian Sugar Planter's Association.

Xylobates oblonga robustior subsp. nov.

Pseudostigmatic organ head slender, the fringe formed of spinelike projections spaced half their length from each other; the number of elements to the fringe varies considerably either on the pedicel or on the head, there occasionally being some on the opposite edge; total length 0.47 to 0.51 mm., breadth 0.29 to 0.32 mm.

COTYPES: Thirty-seven specimens from upper inch of soil, eighty year old pine-oak woodland, Bent Creek Experimental Forest, northeast of laboratory buildings, Asheville basin, N. C.; slide no. 34F21–1.

Oribata oblonga (12, p. 73, Pl. 11, Fig. 37) was described from Columbia, Missouri. A year earlier *Protoribates capucinus* (6, p. 2) was described from Italy and Columbia, Missouri. As most American species found also in Italy differ at least subspecifically, *X. capucinus* must be restricted to Italy, Berlese not recognizing the subspecific difference. With this understanding I will use *X. oblonga* as representing the American species. The length of the Italian individual is given as 0.42 (average or maximum?, probably the latter); the length of *X. oblonga* is given as 0.44 (average or maximum?).

Peloribates curtipilus sp. nov.

Surface smooth; bristles short, nearly straight, stout, burred; pseudostigmatic organs clavate, with short pedicel, head finely barbed in about five rows; length 0.348 to 0.4 mm., breadth 0.238 to 0.26 mm.

COTYPES: Eleven specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F11.

Genus Propelops gen. nov.

Resembling Pelops in arrangement of notogastral bristles and porose areas, in development of pteromorphæ, lamellæ, pseudostigmatic organs, and tectopedia I and II, but differing in having normal mouthparts and unexpanded interlamellar bristles.

TYPE: *Propelops pinicus* sp. nov.

Propelops pinicus sp. nov.

Pseudostigmatic organs porect, clavate, slightly burred; interlamellar bristles very long, stout, slightly burred, extending anteriad and ventrad to end of rostrum; lamellar bristles inserted on under face of lamellæ, sharply

bent, extending mediad beyond rostrum; rostrum covered with rounded, rivet-headlike knobs; rostral bristles short, clavate, fimbriate along edge of head, inserted well back on lower edge of genæ; lamellæ very broad, with slender translamella, nodose (like rostrum); pteromorphæ with anterior edge above tectopedia II undulate, over cephaloprothorax gently convex; notogastral bristles short, stiff, smooth, except a closely spaced posterior pair which are clavate.

COTYPES: Twelve specimens from short-leaf pine litter of isolated stand two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F10.2P2.

Pelops brevipilus sp. nov.

"Eyed"; anterior edge of notogaster triundulate; interlamellar area deeply "excised"; rostrum compressed, slender; lamellar bristles large clavate, blunt; pseudostigmatic organs gently curved, half length of lamellar bristles, slenderly clavate; notogastral bristles short, inconspicuous, posterior edge of notogaster impressed along median line; length 0.34 mm., breadth 0.26 mm.

COTYPES: Thirty specimens from closely browsed Andropogon pasture between wooded slopes, two miles southwest of Bent Creek on Asheville-Brevard road, N. C.; slide 34F11P.

ANALYSIS OF THE FOREST FLOOR ARTHROPODS

Ivar Trägårdh's sensationally written paper (26) concerning my "Evaluation of the forest floor population" (19) cannot be considered as a contribution to scientific (that is impartial and unbiased) literature. I wish, however, to set forth certain facts which he did not trouble himself to secure. While in China I made two attempts to secure his paper of 1929 (25) but he failed to aid me. My paper was written the summer of 1932, and it was not until after the paper had gone to press that I actually saw a copy of his paper while at Ithaca. As it is an exception to those papers I reviewed, I see no reason why I should have included it, especially as it was a brief preliminary (?) paper.

In 1919 I first became interested in determining the exact habitats of Oribatid mites, and have been collecting forest floor material with that idea, carefully separating the various elements of the forest floor. This work I continued while in China. As Trägårdh knows, the analysis of such material is a long and tedious process—especially when each subfamily and even each

species has to be entirely revised (locally) and restudied before specific determinations can be made. A careful study of my habitat data (15, p. 267; 17, p 260) might have revealed this type of collecting. In brief I had not only gone over the European literature with care but had been carrying on fractional, analytical collecting of forest floor material for over ten years before writing as I did.

Trägårdh's own paper of 1929 corroborates my suggestions for future procedure. I have made certain practical suggestions. Trägårdh objects on the ground that it is too difficult (top of page 56). It is the scientist's duty to find a way, and he will. I placed the emphasis on qualitative as opposed to quantitative analysis. This is generally admitted to be a preferable objective. There is certainly no harm in reorienting any future American work along this line. Thus I do not see what axe Trägårdh has to grind except that I omitted considering his own brief contribution.

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For further details on the above references see my "Annotated Bibliography of the Moss Mites (Oribatoidea, Acarina)" and its appendices.

PLATE 26

Oppiella corrugata (from Regensburg)

Figure 1. Midthoracic region, showing ridge of anterior edge of notogaster; ratio × 330.

Oppiella corrugata squarrosa subsp. nov.

Figure 2. Same aspect; ratio × 330.

Oppiella corrugata apicalis subsp. nov.

Figure 3. Same aspect; ratio × 330.

Figure 4. Lateral aspect of prothoracic ridges and pseudostigmatic organ; ratio × 330.

Figures 5 & 7. Pseudostigmatic organ head, anterior aspect; ratio × 440.

Figure 6. Same, dorsal aspect to left of numeral, anterolateral aspect to right; ratio × 440.

Eremulus pectinatus sp. nov.

Figure 8. Pseudostigmatic organs; ratio × 440.

Oppiella foliosa sp. nov.

Figure 9. Dorso/ventral aspects, legs and mouth parts omitted; ratio × 330.

Figure 10. Pseudostigmatic organ, lateral aspect; the one to left of numeral partly cleaned off; ratio × 440.

Figure 11. Shoulder bristle; free hand.

Figure 12. Notogastral bristle, veining indicated; free hand.

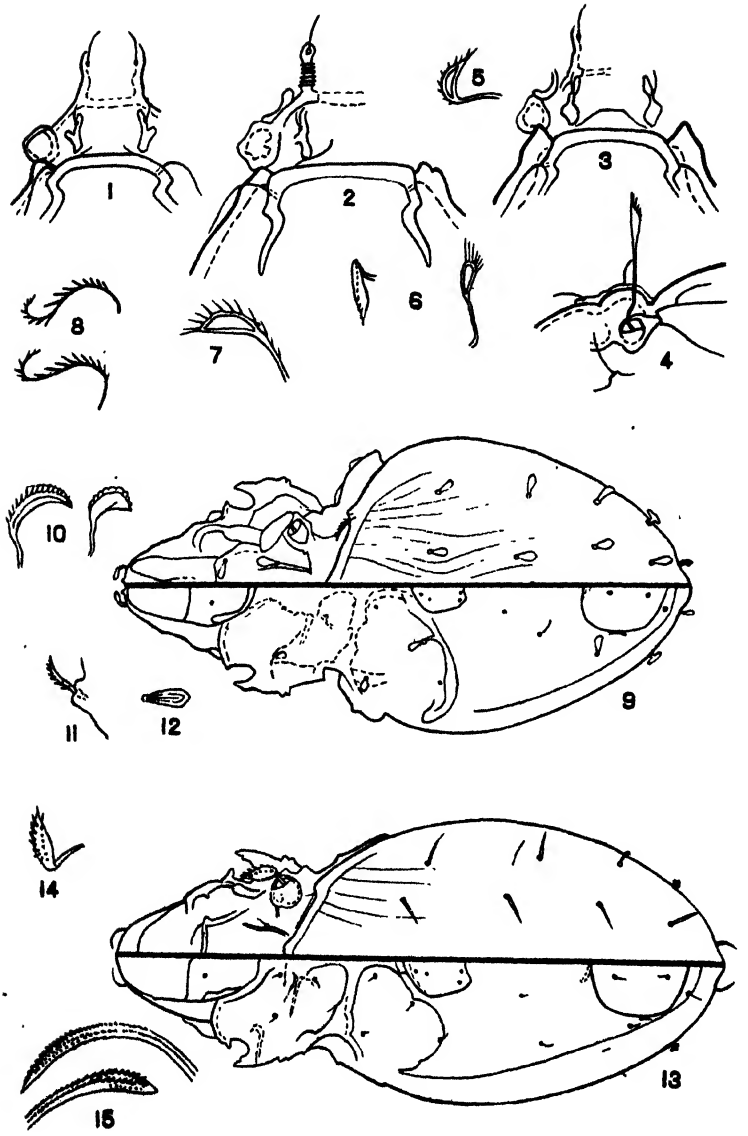
Oppiella stipularis sp. nov.

Figure 13. Dorso/ventral aspects, legs and mouth parts omitted; ratio × 330.

Figure 14. Pseudostigmatic organ, dorsal aspect; free hand.

Carabodes falcatus sp. nov.

Figure 15. Pseudostigmatic organs; ratio × 440.



MOSS-MITES

PLATE 27

Suctobelbella serratirostrum sp. nov.

Figure 16. Dorso/ventral aspects, legs and mouth parts omitted; ratio × 330.
Figure 17. Rostrum, lateral aspect; free hand.
Figure 18. Rostrum, posteroventral aspect; free hand.
Figure 19. Edge of camerostome, anterodorsal aspect; ratio × 440.
Figure 20. Pseudostigmatic organ, side view, showing the several rows of bristles; ratio × 440.

Suctobelbella longicuspis sp. nov.

Figure 21. Rostrum, dorsolateral aspect; ratio × 440.
Figure 22. Pseudostigmatic organs, figure to right of numeral is dorsal aspect, figure to left is somewhat lateral; free hand.

Suctobelbella frothinghami sp. nov.

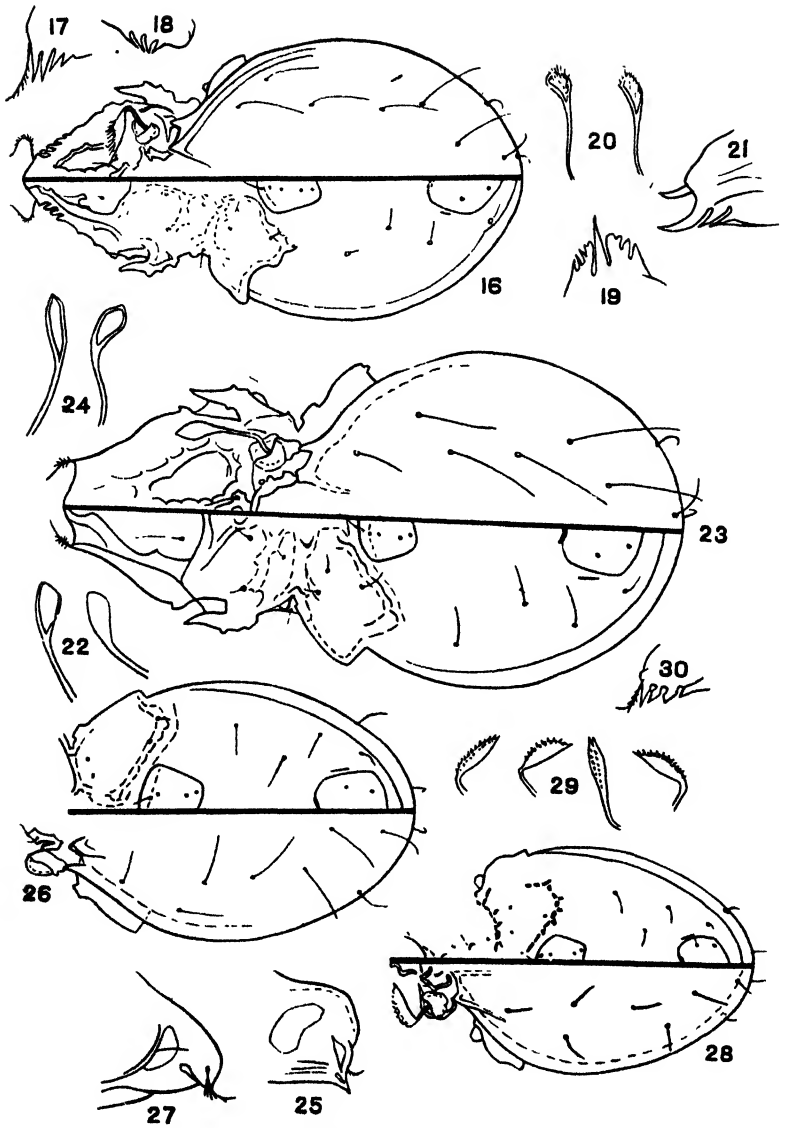
Figure 23. Dorso/ventral aspects, legs and mouth parts omitted; ratio × 330.
Figure 24. Pseudostigmatic organ, slender head to left of numeral, broad head to right; ratio × 440.
Figure 25. Rostrum, lateral aspect; ratio × 440.

Suctobelbella hurshi sp. nov.

Figure 26. Abdomen and part of prothorax, dorso/ventral aspects; ratio × 330.
Figure 27. Rostrum, lateral aspect; ratio × 440.

Suctobelbella laxtoni sp. nov.

Figure 28. Abdomen and part of prothorax, dorso/ventral aspects; ratio × 330.
Figure 29. Pseudostigmatic organs, dorsal aspects, except figure to right of numeral which is lateral aspect; ratio × 440.
Figure 30. Rostrum, lateral aspect; free hand.



MOSS-MITES

SEVENTH INTERNATIONAL CONGRESS FOR ENTOMOLOGY, BERLIN, 1938

By Resolution adopted by the Executive Committee for the International Congresses for Entomology, the

Seventh International Congress for Entomology

will convene in Berlin, from August 15th to 20th, 1938.

Discussions will be held in the following sections and on the subjects indicated below:

A. General Entomology:

(1) Systematism and Zoögeography. (2) Nomenclature and Bibliography. (3) Morphology, Physiology, Embryology and Genetics. (4) Oecology.

B. Applied Entomology:

(1) Medical and Veterinary-medical Entomology. (2) Agriculture and Sericulture. (3) Forest Entomology. (4) Agricultural Entomology, (a) Viticulture and pomiculture. (b) Agriculture and olericulture. (c) Vermin. (5) Means and methods for fighting vermin.

The Management of the Congress will deeply appreciate the participation of numerous Representatives of Scientific and Practical Entomology in the Congress to be convened in Berlin.

All entries for participation, and all inquiries, should be addressed to the Secretary General, Professor Dr. Hering, Invalidenstrasse 43, Berlin N. 4.

ANTHIDIINE BEES IN THE COLLECTION OF THE NATURAL HISTORY MUSEUM OF SAN DIEGO, CALIFORNIA

BY HERBERT F. SCHWARZ

For the opportunity to examine the specimens reported upon in this paper I am indebted to Dr. Clinton G. Abbott, who at the kind suggestion of Professor T. D. A. Cockerell submitted them to me. Although the material does not include any new species, the large series of some of the existing species gives opportunity to demark the range of variability that these species present. Of incidental value may also be the new locality records. Almost without exception the species reported upon were collected in California and for the most part in San Diego County. Because of this fact it has seemed appropriate to add a plate, skilfully drawn by Mr. Pierre-Noël, presenting contrasts as well as resemblances in the structure and the maculation of the clypeus of the female of certain California species of *Anthidium*. The dentition or lack of dentition of the clypeus are characters not infrequently neglected in the descriptions. Although there is sometimes great similarity between the clypeus of two species—for instance, *placitum* (Fig. F) and *edwardsii* (Fig. G)—such species may differ fundamentally in other respects. The female of *placitum*, for example, has a tooth on each side of its apical tergite while the female of *edwardsii* is devoid of such teeth. Nevertheless, comparative study of a character has its interest although not in itself conclusive as to the affinities of the insects that share that character. There is frequently variability in respect to the maculations in a given species, and not always are even the individuals of that species bilaterally symmetrical. A case of asymmetry is shown in the maculation of the clypeus of *collectum* (Fig. D).

Anthidium atripes (Cresson)

(Fig. B)

California.—Laguna Mts., San Diego County, June 29, 1921, 1 ♀ and 1 ♂; Laguna, San Diego County, June 7, 1926, 3 ♂♂,

collected by W. S. Wright; Pine Valley, San Diego County, June 27, 1927, 1 ♂; without locality designation, 1 ♀.

This species, which Cresson originally described merely as a variety of *emarginatum*, although structurally as well as in its maculations it is distinct, is nevertheless much more variable than I had been led to believe from an examination of the few specimens that up to the present have been available. Cresson's type —a male—is largely covered with black hair instead of the silvery hair so characteristic of the vast majority of the males of *Anthidium*. In the present series the males all have silvery hairs greatly predominant; in most of them indeed the black hairs are traceable, if at all, only on the under side of the abdomen and on the metatarsi (especially those of the middle pair of legs), but even in these areas the pale hairs greatly outnumber the darker ones. What makes for pause in separating these insects from typical *atripes* is that similar diversity in the color of the hairs, presenting both of the extremes as well as intermediate conditions, occurs in other species (*vide* Cockerell, 1925, Proc. Cal. Acad. Sci., (4), XIV, p. 356; Schwarz, 1927, Amer. Mus. Novitates, No. 252, pp. 1–5, and Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 372–377).

Not only is there variability in respect to the color of the hairs but also with respect to the maculations. Of the five males submitted by the Natural History Museum of San Diego, four resemble the type in having either wholly black legs (as indicated in Cresson's description of *atripes*) or at most a tiny spot—easily overlooked—at the base of the fore tibiæ. The fifth specimen—one of those from Laguna—has a larger maculation at the base of both the fore and the middle tibiæ, a stripe at the apex of the fore tibiæ supplemented by a maculation at the base of the fore metatarsi, and a splash of color near the apex of the fore femora. In all the five males the bands on the tergites are "deeply emarginate and interrupted" and in three of these males tergites 5, 6, and 7 are entirely black, showing in this respect a greater degree of melanism than the type, which has at least two dots on tergite 5 although it has tergites 6 and 7 black. However, by way of offset, the other two male specimens have the abdomen more maculated than the type. One of them—a specimen from Laguna with

black legs—has on tergite 5 two quadrate spots with a transverse line extended laterad from the apex of each of them, on tergite 6 two spots of irregular shape, on tergite 7 two spots localized on the lateral lobes. The other—likewise a specimen from Laguna with wholly black legs—agrees with the type in having two small maculations on tergite 5 and an immaculate tergite 6 but differs in having the lateral lobes of tergite 7 each with a maculation.

The two females submitted have more black hairs than the males, yet are not as dark in appearance as the female I described (Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 389–390). Virtually the entire head (except for a few interspersed black hairs on the clypeus in the specimen without locality designation) and the sides of the thorax as well as the mesonotum are covered with silvery hairs. The hairs of the legs, too, are mainly pale although the metatarsi and other tarsal joints and to some extent also the tibiæ, especially the middle and hind pair, have considerable dark hair. In the specimen without locality designation the hairs on tergites 5–6 and on the apex of tergite 4, as well as the ventral scopa, are black. In the female from Laguna Mts. the ventral scopa is black except for a few silvery bordering hairs at the side, but the two apical tergites, instead of black, have for the most part silvery hairs thinly interspersed with black. The two females in question agree with the female I described in having the legs immaculate, and one of them is in further agreement with that female in also having tergites 5–6 immaculate. In the other specimen tergite 6 is immaculate but tergite 5 has two faint spots. Tergites 3–4 are more fully maculated in these two females than in the female I described although their maculations are not of uniform extent, and both of them have the lateral halves of the band on tergite 1 without emargination—in one of the two specimens, however, this band has imbedded dark spots. In both of these females the axillæ as well as the scutellum are maculated whereas in the accompanying males it is only the scutellum that has yellow spots.

Anthidium banningense Cockerell

(Fig. C)

California.—Lake Tahoe, July 8, 1926, 1 ♀ and 1 ♂, collected by W. S. Wright.

These are the only two specimens in the collection from Lake Tahoe and the fact that the female accords with the specimens that I have previously interpreted as that sex of *banningense* (Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 390–391) lends support to the correctness of that association.

Anthidium collectum Huard

(Fig. D)

California.—Laguna, San Diego County, June 7, 1926, 1 ♂, collected by W. S. Wright; Warner's, San Diego County, Aug. 6, 1921, 1 ♂; San Diego, April 20, 1921, 1 ♀.

The last visible sternite of the male of *collectum* has like the corresponding sternite of *palliventre* a triangular emargination at the apex of its middle element, but the lateral spines of this sternite are shorter and sharper in *collectum* than in *palliventre*, while the exterior lobes of the pygidium are in *collectum* rather straight at least along their outer margin whereas in *palliventre* they are shaped somewhat like the horns of a crescent. The strong yellow stripes on the external surface of the tibiæ still further differentiate the male of *collectum* from the male of *palliventre* with its black tibiæ.

Anthidium clypeodentatum lutzi Schwarz

(Fig. A)

California.—Warner's, San Diego County, Aug. 1, 1921, 1 ♀.

The single female here reported upon differs slightly from the original description of this variety (Schwarz, 1928, Jour. N. Y. Ent. Soc., XXXVI, pp. 380–381). In contrast with the condition in the type of *lutzi*, the apex of the clypeus is strongly dentated medianly as well as laterally, with a total of seven clearly defined teeth. In typical *clypeodentatum* there is considerable variability in the dentition of the clypeus (see Schwarz, 1928, Canadian Entomol., LX, pp. 215–216) and it is to be presumed that there is a similar range of variability in the variety *lutzi*. There is a clearly defined carina down the middle of the clypeus in the specimen from Warner's that is sometimes only obscurely present in typical *clypeodentatum*. The black area down the middle of the clypeus is more extensive in the present specimen

than is indicated for the type, somewhat suggesting the condition in *placitum*. The specimen lacks a maculation on the mesopleura, has the hind coxæ black, and the stripes on the under side of the femora confined to the apical half. However, the variability in the maculations of Anthidiines, even when a given species is obtained from a single locality, is apt to be considerable and accordingly I place this specimen in the variety *lutzi*, with which it agrees in so many essentials.

Anthidium fontis Cockerell

(Fig. E)

California.—Warner's, San Diego County, July 29, 1921, and Aug. 1–6, 1921, 2 ♂♂.

Anthidium maculosum Cresson

(Fig. H)

California.—San Diego, July 20, 1920, 1 ♂, collected by W. S. Wright; Warner's, San Diego County, Sept. 1920, 3 ♀♀ and 6 ♂♂, collected by George H. Field; Pine Valley, Aug. 1, 1927, 1 ♀, Aug. 6–21, 1927, 3 ♀♀ and 1 ♂. Arizona.—Summerhaven, Alt. 7700 ft., Santa Catalina Mts., Aug. 12, 1934, 1 ♀, collected by Ian Moore. There are also four males without locality designation bearing the following accession numbers: 631 (two of them), 638, and 591.

The females of this series are rather constant from specimen to specimen in respect to their maculations. The males also differ relatively little. Most of them have the middle and hind metatarsi yellow externally but the fore metatarsi black; on the other hand, there are some that have yellow also on the front metatarsi, usually in such cases over the entire outer surface of the joint but in one instance only over the basal half.

Anthidium mormonum fragariellum (Cockerell)

California.—Laguna, San Diego County, June 16, 1926, 1 ♂, collected by W. S. Wright.

This specimen, like Cockerell's type of *fragariellum*, has "a pair of large cuneiform patches, deeply incised posteriorly" on tergite 1 of the abdomen.

Anthidium placitum Cresson
(Fig. F)

California.—Pine Valley, San Diego County, 2 ♀♀ and 1 ♂, Aug. 1, 1927, collected by F. W. Kelsey, and 15 ♀♀ and 18 ♂♂, Aug. 6–21, 1927.

This large series—all from a single locality and collected in the course of a single month—nevertheless shows variability in its markings. Of the males some have the scape in front fully maculated, others only partly maculated, others not at all. The maculation above the summit of the eye of the male is sometimes merely spot-like, sometimes linear and extended inward for a distance as great or greater than that which separates the maculation from the corresponding maculation above the other eye. All of the males have L-shaped stripes antero-laterally on the mesonotum, a maculation on the axillæ that is confluent with a broad stripe-like maculation bordering the posterior half of the scutellum except for a brief interruption at the middle, maculated tubercles, and a maculation anteriorly and a smaller maculation posteriorly on the tegulæ. All of the males, too, have stripes on all of the femora but of somewhat variable development, and all of them have the tibiæ and tarsi externally yellow. In seventeen of the males the propodeum is wholly black but two have yellow maculations in this region—a condition more usual in the female. Throughout the series all seven tergites bear maculations but not of altogether uniform richness, some of the males being quadrimaculate on tergite 1, others bimaculate. The degree to which the bands on the subsequent tergites are emarginate above also varies as does the degree of the fusion or separation of the two halves of the bands on tergites 4 and 5.

In the females there is also variability. I have already discussed the instability of maculation in the female of *placitum* in a previous paper (1927, Amer. Mus. Novitates, No. 252, p. 17). The differences there noted in the few specimens then available, likewise from San Diego County, are confirmed and extended in the much larger series now before me. In many of the specimens the stripe on the scape is confined to the base, in other cases it runs from base to apex, in two specimens the stripe is absent. The band of black down the middle of the otherwise yellow clypeus

is of variable width, sometimes terminates before reaching the apex, and in rare instances has almost disappeared. The stripe on the vertex is sometimes nearly continuous, at other times interrupted by a space equalling that between the lateral ocelli; in none of the females are these maculations merely spotlike as in some of the males. The thorax of the females viewed from above is maculated as is that of the males, the maculations being pretty well standardized from specimen to specimen. On the other hand, the two spots on the propodeum that in a key to the females of *Anthidium* (1927, Amer. Mus. Novitates, No. 253, p. 15) I used as a character for the separation of *placitum* are of very variable development, are faint in several of the specimens, and in three cases out of the seventeen even lacking. The legs in all the specimens are predominantly yellow, but there is some variability nevertheless in the extent of the surviving black areas on the femora and elsewhere. In only one of the specimens before me is the band on tergite 1 subdivided into four parts; in all the other cases there is merely a median division, the two halves posteriorly emarginate. The degree of fusion or separation medianly of the bands on tergites 4–5 shows variability as in the male, tergite 5 being almost invariably continuous although emarginate. It is somewhat exceptional to find the maculation on tergite 6 of the female completely subdivided into two spots although the two elements are frequently semidetached.

Callanthidium illustre (Cresson)

California.—Pine Valley, San Diego County, Aug. 1, 1927, 2 ♂♂, collected by F. W. Kelsey.

Dianthidium parvum swenki Schwarz

California.—Pine Valley, San Diego County, Aug. 6–21, 1927,

Dianthidium pudicum consimile (Ashmead)

California.—Warner's, San Diego County, Sept. 1920, 1 ♀, 1 ♂, collected by George H. Field; Pine Valley, San Diego County, Aug. 1, 1927, 1 ♀.

The females are doubtfully assigned to *consimile*. Their maculations are in accord with those of *consimile* but the slightly curvilinear emargination between the second tooth of the mandible and

the inner angle of the mandible is more indicative of the condition usually observed in *davidsoni*. It is possible, therefore, that the females in question are slightly undermaculated representatives of *davidsoni*.

Dianthidium ulkei davidsoni (Cockerell)

California.—Pine Valley, San Diego County, Aug. 6–21, 1927, 2 ♂♂.

Anthidiellum robertsoni (Cockerell)

California.—Warner's, San Diego County, July 29, 1921, 1 ♀; San Diego, July 27, 1921, and Aug. 25, 1921, 2 ♂♂; Pine Valley, San Diego County, Aug. 6–21, 1927, 1 ♂.

In two of the males the inverted T-shaped figure in black on tergite 6 is imperfectly formed, one of them having a black area only in the region between the tuberculate prominences without the supporting shaft of the T. In this specimen tergites 4–5 are not four-spotted after the usual manner but are bimaculate with a semienclosed black spot apically in each of the maculations.

Paranthidium jugatorium variety **perpictum** (Cockerell)

Arizona.—Summerhaven, alt. 7700 ft., Santa Catalina Mts., Aug. 18, 1934, 2 ♀♀ and 1 ♂, collected by Ian Moore.

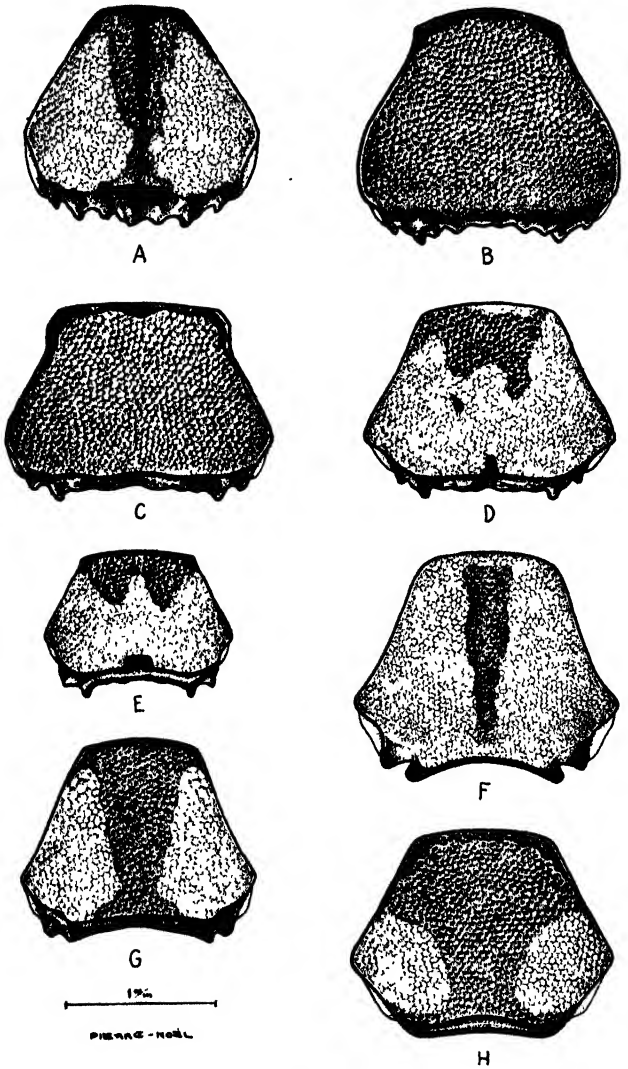
One of the females has a virtually continuous band across the vertex and rather broader lateral face-marks than is usual in the variety *perpictum*, in these respects somewhat resembling the variety *lepidum* of the Southeast.

The variety *perpictum* is known to occur in New Mexico and Colorado. This is, I believe, the first record of its occurrence in Arizona.

PLATE 28

Clypeus of Female of California Species of *Anthidium*

A. *Anthidium clypeodentatum lutzi* Schwarz
B. *Anthidium atripes* (Cresson)
C. *Anthidium banningense* Cockerell
D. *Anthidium collectum* Huard
E. *Anthidium fontis* Cockerell
F. *Anthidium placitum* Cresson
G. *Anthidium edwardsii* Cresson
H. *Anthidium maculosum* Cresson



ANTHIDIUM

BOOK NOTICE

A Glossary of Entomology. Smith's "An Explanation of Terms Used in Entomology." Completely revised and rewritten. By J. R. de la Torre-Bueno, Brooklyn Entomological Society, Brooklyn, N. Y., 1937. $5.00. ix + 336 p. Pl. I–IX. Blue cloth binding, gold lettering.

Twenty-six years ago when I first started to work under Dr. John B. Smith, one of the first books I purchased at that time was a copy of his "Explanations of Terms used in Entomology," which had been published by the Brooklyn Entomological Society in 1906. Having always had a weakness for glossaries, catalogues, directories, and check-lists, it is easy for me to be pleased with Mr. Torre-Bueno's new "Glossary of Entomology," in its attractive blue binding, and with its well printed, legible pages.

To be satisfactory and usable, a glossary should contain, within reason, all terms in current use within its field and I am sure that entomologists will find this new glossary meeting this requirement. The author's position with respect to highly specialized and little used terms, as explained in the introduction, is sound.

Both the author and the publisher should receive the commendation of entomologists for this much needed, and highly useful contribution to entomological literature. The Brooklyn Entomological Society has always encouraged and promoted worth-while contributions to entomology.—H. B. W.

NEW NORTH AMERICAN FUNGUS GNATS (MYCETOPHILIDÆ)

BY ELIZABETH FISHER

Fifteen undescribed species of fungus gnats were found, while working over some material in the insect collection of Cornell University, as well as new locality records for six others. As thirteen new species of the genus Bolitophila have been described since Johannsen's key to the genus appeared in 1909 (Maine Agr. Exp. Sta. Bull. 172) and two more species are described in this paper it seems well to include a key to the species of that genus. Eight new eastern species of the genus Mycomyia are described in this paper and a key to these is therefore included. The key to the genus Bolitophila includes all the North American forms; the western forms are inserted on the basis of the original descriptions except for *B. bilobata, B. subteresa,* and *B. perlata* for which paratype material was available. The key to the genus Mycomyia includes only the species of the Atlantic states; western forms are omitted because of lack of material.

I wish to express my thanks to Mr. Frank R. Shaw for his generous loan of specimens; among them the paratypes mentioned above, and also for the specimens upon which the new record of *Bolitophila perlata* and the description of *Mycomyia dentata* are based. He has also looked over many of the new species described here, but for any errors he is in no way responsible.

KEY TO MALES OF THE GENUS BOLITOPHILA OF NORTH AMERICA

1. Vein R_4 ending in C 2
   Vein R_4 ending in R_5 11
2. Petiole of Cu atrophied at base 3
   Vein Cu_1 atrophied at base . . . . . *disjuncta* Loew
   Petiole of Cu and Cu_1 not atrophied at their bases 4
3. Styles with tips "spoon-shaped with the tip chitinized" (*i.e.*, sclerotized). *clavata* Garrett
   Styles with tips bifid . . . . . *recurva* Gar.
4. Cu_2 joins the anal vein near its distal end 5
   Cu_2 does not join the anal 6

5. Styles "small, tips bifid, about equal in length" ..... *connectans* Gar.
   Styles not bifid ..... *alberta* n. sp.
6. Styles with the inner tip ending in a sclerotized point ..... *acuta Gar.*
   Styles not so 7
7. Sc ends proximad of the base of R_s 8
   Sc ends distad of the base of R_s 9
8. Thorax light in color ..... *distus* n. sp.
   Thorax dark in color ..... *moiana Coq.*
9. Stigma subobsolete; styles "oval with a nose-shaped inner lobe below the middle directed inwards" ..... *bilobata* Gar.
   Stigma brown; styles not as above 10
10. Styles "sausage-like with the tip constructed smaller, this smaller part ending in two tips" ..... *subteresa* Gar.
    Styles broad ending in two diverging tips ..... *hybrida* Meig.
11. Cu_1 arises apparently at M either by the fusion with M or by the reduction of the m-cu cross-vein 12
    Cu_1 arises below M; m-cu cross-vein distinct 16
12. Cu_1 fused with M; R_4 straight 13
    Cu_1 arises at M; m-cu cross-vein being greatly reduced 14
13. Subobsolete stigma ..... *atlantica* Fisher
    Stigma brown ..... *dubiosa* Van Duzee
14. Styles "scoop-shaped (tips truncate with one corner ending in a chiton point" ..... *duplus* Gar.
    Styles "long, base narrow, tip wider and bifid, outer branch short, inner longer and directed in and upwards" ..... *patulosa* Gar.
    Styles not so 15
15. Styles without teeth ..... *cinerea* Meig.
    Styles with a subterminal ventral knob, and two terminal dorsal teeth. ..... *perlata* Gar.
    (Eastern form)
16. Styles "arcuate, the chitin tips spiral, appearing bifid, with two strong teeth, unique form" ..... *perlata* Gar.
    (Western form)
    Styles "round tapering to a narrow tip shape, the rim chitinized and with two or three black chitin points directed inwards and bristly hairs" ..... *raca* Gar.
    Styles with an inner sclerotized blade at tip; dorsal edge of the zygosternum with a mesally projecting lobe ..... *cinerea* Meig.
    Styles "short dorsally, the base thick, outwardly about halfway straight, then angling to the inner tip. The top truncate" ..... *simplex* Gar.

Bolitophila acuta Garrett

A male and a female taken at Coy Glen, New York, May 26, 1934, I place as belonging to this species. This form has hitherto only been recorded from British Columbia. Hypopygium as in figure 3.

Bolitophila perlata Garrett

This species has been taken in the East by C. P. Alexander on the Gaspé peninsula and in Connecticut. The eastern forms have a shorter m-cu cross-vein; the structure of the hypopygium is like that of a western paratype.

Bolitophila alberta new species.

MALE. Length 5 mm Antennæ fuscous; scape and basal joint of flagellum except its extreme distal end yellow; longer than the head and thorax. Palpi fuscous. Thorax light brown; mesonotum vittate; pleura darkest on anepisternites, sternopleurites, and pteropleurites; scutellum and postnotum dark. Abdomen brown; darkest on the tergites of the first and eighth segments and the posterior margins of segments four, five, six, and seven. Coxæ, trochanters, and femora yellow; tibiæ and tarsi subfuscous; fore tibiæ .94 as long as the fore basitarsi. Wings cinereous tinged; veins brown; pale subobsolescent stigma; Sc enters C distad of midway between the humeral cross-vein and the base of R_s; R_4 is straight and ends in C; base of R_s longer than r-m; petiole of M slightly shorter than the base of R_s; m-cu cross-vein is obsolete; Cu_2 curves to join the 2nd anal near its tip. Wing as long as body. Hypopygium as in figure 2.

One male taken at Jasper, Alberta, August 15, 1934. Type (No. 1406) in the Cornell University Collection. This male differs from the male of *Bolitophila montana* Coq. from Ithaca, New York, in the Johannsen collection in having the base of R_s longer, in having Cu_2 curved towards the tip of the 2nd anal, but not fused with it, and in having R_4 slightly oblique.

Bolitophila distus new species.

MALE. Length 5 mm. Antennæ fuscous; scape and basal flagellar joints yellow; palpi yellow. Thorax yellow; mesonotum with a subobsolete brown vitta on each side. Abdomen brown becoming darker distally. Coxæ, trochanters, and femora yellow; tibiæ and tarsi subfuscous; fore tibiæ .88 as long as the fore basitarsi. Wings hyaline; veins brown; pale subobsolescent stigma; Sc enters C slightly proximad of the base of R_s; m-cu cross-vein very short and thick almost obsolete; R_4 ends in C; Cu_2 curves towards the 2nd anal but enters the wing border the length of the petiole of M from the tip of the 2nd anal. Hypopygium as in figure 1.

One male taken at Old Forge, New York, July 20, 1905. Type (No. 1407) in the Cornell University Collection. Close to *B. montana* but differs in the structure of the hypopygium and in color.

Platyura pellita new species.

MALE. Length 4.5 mm. Head fuscous; vertex black; face, mouth parts, palpi, scape, base of first flagellar joint and the ventral half of the first and second flagellar joints yellow; antennæ not compressed. Thorax yellow; mesonotum slightly infuscated mesad; prothorax with black setæ; mesopleura and metapleura bare; first thoracic spiracle with about five hairs on its posterior margin. Legs yellow with black hairs; fore tibiæ longer than the fore basitarsi; distal end of the fore tibiæ with an area of minute reddish brown setæ so closely set together as to appear furry. Wings hyaline; tips very slightly infuscated; Sc ends before the origin of R_s; R_{2+3} slightly oblique, ending in C slightly more than its own length beyond R_1; coalesced part of M a little over half as long as the petiole of M; anal vein reaches the margin. Halteres yellow with one strong seta at the base of each. Abdomen yellow except the brown basal half of each tergite. Hypopygium as in figure 11.

Type from N. E. Margaree, Cape Breton I., Nova Scotia, Sept., 1935. Paratype Ithaca, New York, Sept. 5, 1922. Type (No. 1420) in the Cornell University Collection; paratype in my collection.

This species runs to *Platyura setiger* in Johannsen's key (Maine Bull. 172) but differs greatly in coloration and in hypopygium.

Neoempheria digitalis new species.

MALE. Length 5.5 mm. Robust. Head yellow; antennæ yellow, flagellum darker apically; ocellar spot and palpi black. Thorax mainly yellow; mesonotum darker; pleurotergites slightly infuscated; prothorax with six prominent setæ; anepisternites, pteropleurites and pleurotergites bare; mesonotum with strong setæ, more conspicuous at the base of the wings; setæ in rows on the dorsum; scutellum with two very strong setæ. Wings hyaline; apex with a brown cloud extending from the tip of R_1 to the tip of Cu_1; spot behind Cu_2; Sc_2 and base of small cell R_1 with spot; Sc ends in C over the middle of cell R_1; cell R_1 a little less than three times as long as broad; petiole of M about half as long as M_1; Cu forks just proximad of the r-m cross-vein; C produced just slightly beyond R_5. Halteres yellow. Abdomen mainly yellow; hind margin of the first tergite dark; third tergite with two dark spots on the hind margin; fourth, fifth, and sixth tergites with basal spots that extend caudad along the median line; fifth also with lateral black spots; seventh tergite infuscated except its yellow base; venter yellow. Hypopygium (figure 18) yellow; its digit-like spines black.

Type from Douglas Lake, Mich., August 12, 1922. This species runs to *N. macularis* Joh. in Johannsen's key (Maine Bull. 180). *N. digitalis* is larger; differs greatly in its hypopygial structure from *N. macularis;* cell R_1 is not entirely covered by a spot; and the palpi are black.

A female from Douglas Lake, Mich., is similar to the male except it is about 6.5 mm. in length; has a differently colored abdomen with the dorsum of the first tergite, the hind margins of the second and third, all of the fourth segment except the base, and the remaining tergite dark; venter yellow.

Type (No. 1418) and allotype in the Cornell University Collection.

KEY TO THE MALES OF THE GENUS MYCOMYIA OF THE ATLANTIC STATES

Mycomyia nugatoria, M. onusta, M. unicolor and *M. incompta* are known from the females only and are therefore omitted from this key.

1. Fork of Cu below or distad of the base of R_s 2
   Fork of Cu proximad of the base of R_s 17
2. Spurs present on the mesothoracic coxæ; usually two scutellar bristles 3
   Spurs absent; usually four scutellar bristles 6
3. Fore basitarsus longer than its tibia 4
   Fore basitarsus shorter than its tibia *appendiculata* Lw.
4. Petiole of M longer than M_3 *sequax* Joh.
   Petiole of M shorter than M_3 5
5. Coxal spurs short *imitans* Joh.
   Coxal spurs long; hypopygium figures 7 & 9 *dichaeta* n. sp.
6. Abdomen with two or three spots on each segment; petiole of M shorter than M_3 *biseriata* Lw.
   Abdomen not marked as above; petiole of M equal, shorter than, or longer than M_3 7
7. Hypopygium as in figure 10 *dentata* n. sp.
   Hypopygium not so 8
8. A dense brush of setæ on the fore coxæ *ornata* Meig.
   No dense brush of setæ on the fore coxæ 9
9. Sc ends in R_1 10
   Sc ends in C or is free 11
10. Thorax vittate; base of first abdominal segment dusky *littoralis* Say
    Thorax not vittate; hypopygium figure 5 *alternata* n. sp.
11. Petiole of M shorter than M_3 12
    Petiole of M longer or subequal to M_3 13
12. Abdomen yellow; posterior third or half of each tergite blackish, sixth and seventh tergites black; 3 to 5 mm. in total length *brevivittata* Coq.
    Abdomen yellow; tergites black except the wide posterior margin; 6 mm. in total length *mendax* Joh.
13. Dorsum of thorax fuscous black, with black pile; humeri yellowish; scutellum fuscous black *obtruncata* Lw.
    Thorax yellow with dorsal markings 14
14. Dorsum of thorax with distinct black or reddish markings; Sc_2 usually at the middle of cell R_1 15

Dorsum of thorax with faint markings; Sc_2 before the middle of cell R_1; petiole of M and M_3 subequal ..... *nigricauda* Adams

15. Two scutellar bristles ..... *sigma* Joh.
Four scutellar bristles 16

16. Mesonotum with two oblique lines which meet at the scutellum; a median stripe and two elongate lateral spots dorsad of the wing bases. *obliqua* Say
Mesonotum with three confluent or subconfluent dusky stripes. *tantilla* Say

17. No spurs on the mesothoracic coxæ; fore tibiæ longer than their basitarsi; four scutellar bristles 18
With spurs present on the mesothoracic coxæ; two or four scutellar bristles 19

18. Thorax yellow; bases of abdominal segments black; total length 5 mm. *flavohirta* Coq.
Thorax dark; hind borders of abdominal segments black, bases yellow; hypopygium figures 4 & 8 ..... *turitella* n. sp.

19. Spurs of the mesothoracic coxæ minute; posterior margins of abdominal tergites black; fore basitarsus longer than its tibia ..... *imitans* Joh.
Spurs of mesothoracic coxæ long 20

20. Scutellum with four setæ 23
Scutellum with two setæ 21

21. Sc_2 ends before the center of cell R_1; length 3.5 mm.; both anterior and posterior margins of the tergites yellow; hypopygium as in figures 13, 14, 15 ..... *hirticollis* Say
Sc_2 ends before the center of cell R_1, sometimes but slightly so; abdomen fuscous with yellow posterior margins 22

22. Fore basitarsus shorter than its tibia; hypopygium as in figures 12 & 13. *curvata* n. sp.
Fore basitarsus longer than its tibia; hypopygium as in figures 20 & 21. *scopula* n. sp.

23. Length 6.5 mm.; thorax yellow; three stripes on the mesonotum dark brown, middle one produced cephalad, laterals short, all three confluent posteriorly; hind coxæ infuscated; head infuscated becoming darker near the ocelli ..... *maxima* Joh.
Not as above 24

24. Coxæ fuscous; hypopygium as in figure 22, its dorsal aspect similar to that of *M. scopula* in figure 20 ..... *parascopula* n. sp.
Coxæ yellow 25

25. Pleura yellow; scutellum yellow; head infuscated ..... *sequax* Joh.
Pleura blackish; scutellum blackish; head shining black; hypopygium as in figure 19 ..... *pseudomaxima* n. sp.

The European species, *Mycomyia ornata* Meig., was taken at McLean, New York, in August. The postnotum has the characteristic few bristles and the fore coxæ have the brush-like group

of setæ. There are two types of hypopygia represented. One is like that figured by Edwards (Trans. Lond. Ent. Soc., 1925); this specimen has the fore tibia subequal to the fore basitarsus. The other is like that figured by Dziedzicki (Publications de la Société des sciences de Varsovie III. 1915.) as *Sciophila tumida* Winn.; this specimen has the fore basitarsus longer than its tibia. Edwards suggests that *M. tumidia* is a synonym of *M. ornata*. He says: "The male hypopygium shows a certain amount of variation but most of those I have examined agree more or less closely with Dziedzicki's figures of *Mycomyia tumida*. For this reason I think it possible that Dziedicki has merely figured as *M. ornata* an abnormal or damaged specimen of the same species which he has shown in a different position as *M. tumida*."

Two other North American species have this fore coxal brush, *Mycomyia durus* Garrett and *Mycomyia armata* Garrett.

Mycomyia hirticollis has been taken on Cape Breton Island, Nova Scotia, in August. Figures 13, 14, and 15 show the hypopygium of this species; they are included here as there are no published figures of this species.

Mycomyia sigma Joh. originally recorded only from North Carolina has been taken at the Wild Flower Preserve, Slaterville, New York, and also at Fillmore Glen, Moravia, New York.

Mycomyia sequax Joh. originally recorded from Ithaca, New York, has been taken at Jasper, Alberta.

Mycomyia pseudomaxima new species.

MALE. Length 2.5 mm. Head black; palpi, scape, and base of first flagellar joint yellow; proboscis dusky. Thorax dusky black except the prothorax and the membraneous areas surrounding the stigmata and the wing bases. Legs yellow; spurs of the mesothoracic coxæ slender, reaching up to about two thirds the length of the fore coxæ, the tip bearing two minute black teeth; fore tibiæ longer than the fore basitarsi. Halteres yellow. Wings hyaline; Sc ends in C over distal end of cell R_1; Sc_2 over middle of cell R_1; cell R_1 about twice as long as wide; R_{4+5} ends nearly at the wing tip; the petiole of M longer than M_3; Cu forks below the r-m cross-vein. Abdomen fuscous; venter and the narrow posterior margins of tergites yellow. Hypopygium (superficially like *M. maxima*) as in figure 19.

Holotype taken at Ithaca, New York, May 24, 1934. Type (No. 1411) in the Cornell University Collection.

Mycomyia parascopula new species.

MALE. Length 4 mm. Head black; palpi subfuscous; scape subfuscous (flagellum missing). Thorax mainly fuscous; prothorax yellow with four or five subprominent setæ; mesonotum with three fuscous stripes, the laterals abbreviated anteriorly, the three confluent caudad; scutellum yellowish with four prominent setæ; postnotum and pleura fuscous. Legs yellow; posterior coxæ fuscous; spurs on the mesothoracic coxæ longer than the coxæ, tapering distally to the two black terminal teeth. Wings hyaline; Sc ending in C distad of the middle of cell R_1; cell R_1 less than twice as long as wide; petiole of M shorter than M_3; C ends at R_{4+5} at the wing tip; Cu forks proximad of the r-m cross-vein. Halteres yellow. Abdomen fuscous; posterior margins of the tergites yellow. Hypopygium as in figure 22.

Type from Beltsville, Md., Oct. 22, 1915. W. L. McAtee collector. Type (No. 1410) in the Cornell University Collection.

Mycomyia dichaeta new species.

MALE. Length 4 mm. Head brown; proboscis, palpi, scape, and basal joint of flagellum yellow. Thorax mainly yellow; prothorax yellow with two prominent and five smaller setæ on each side; mesonotum with three stripes, a median brown stripe produced to the anterior margin, two lateral brown stripes abbreviated anteriorly, the three stripes confluent posteriorly before the level of the wing bases, the remainder of the mesonotum dark brown; scutellum and postnotum brown, yellow laterally; anepisternites and sternopleurites brown; pleurotergites brown on their ventral and caudal margins; scutellum with two prominent setæ. Legs yellow; distal end of hind coxæ with an oblique line of short setæ on their caudal aspects; mesocoxal spurs long slender tapering gradually to a point which lacks teeth; fore tibiæ and fore basitarsi subequal in length. Wings hyaline; C ends at R_{4+5}; Sc long ending in C just proximad of the middle of cell R_1; Sc_2 over proximal end of cell R_1; cell R_1 over twice as long as wide; R_{4+5} ends at the wing tip; petiole of M less than half as long as M_3; Cu forks distad of the r-m cross-vein; indications of a spurious vein between R_5 and M which ends before the wing margin. Abdominal segments brown with broad yellow posterior margins. Hypopygium as in figures 7 and 9.

Type from Fillmore Glen, Moravia, New York, June 28, 1935. Paratypes from the Wild Flower Preserve, Slaterville, New York, and Lick Brook, Ithaca, New York, Oct. 10, 1935. Type (No. 1415) in the Cornell University Collection. Paratypes in my collection.

Mycomyia scopula new species.

MALE. Length 4 mm. Head dark brown; proboscis, palpi, scape, and basal joint of flagellum yellow. Thorax mainly yellow; prothorax yellow with three

to five prominent setæ; mesonotum yellow with three faint stripes, the median one continued anteriorly to the collar, the laterals abbreviated anteriorly; postnotum and sternopleurites slightly infuscated. Legs yellow; fore basitarsi longer than their tibiæ; mesothoracic coxæ with long spurs, each tapering to a black tip. Wings hyaline; C ends at R_{4+5}; Sc long ending in C just beyond the middle of cell R_1; Sc_2 just beyond the middle of cell R_1; cell R_1 twice as long as wide; R_{4+5} ending at the wing tip; petiole of M longer than M_3; Cu forks below the r-m cross-vein. Abdomen fuscous; venter and narrow posterior margins of the tergites yellow. Hypoygium (superficially like *M. maxima*) as in figure 19.

Holotype taken at Ithaca, New York, May 24, 1934. Type (No. 1411) in the Cornell University Collection.

Mycomyia turitella new species.

MALE. Length 3.5 mm. Head fuscous dorsally; front and lateral portions yellowish; palpi yellow their proximal ends darker; antennæ light brown except the scape and basal flagellar joint which are yellow. Thorax mainly yellow; three confluent stripes on the mesonotum, the median light brown and continued anteriorly to the collar, the laterals abbreviated anteriorly and black in color; lateral portions of the mesonotum above the wing bases and anterior as far as the ends of the lateral stripes fuscous; prothorax and humeri yellow; prothorax with four prominent bristles; scutellum fuscous with four subprominent bristles; postnotum yellow, fuscous caudad; anepisternites, sternopleurites, and pleurosternites fuscous. Coxæ yellow; mesothoracic coxæ without spurs; fore tibiæ longer than fore basitarsi. Halteres yellow. Wings hyaline; Sc long ending in C over the distal end of cell R_1; Sc_2 over the middle of cell R_1; C ends at R_{4+5} before the wing tip; cell R_1 about twice as long as wide; petiole of M shorter than M_3; Cu forks proximad of the r-m cross-vein. Abdomen fuscous; bases of tergites yellow. Hypopygium as in figures 4 and 8.

Described from one male collected by W. A. Hoffman at Monticello, Fla., March 8, 1919. Holotype (No. 1408) in the Cornell University Collection.

Mycomyia curvata new species.

MALE. Length 5 mm. Head fuscous; palpi, scape, and basal third of first flagellar joint yellow. Thorax fuscous, prothorax yellow with five subprominent setæ; mesonotum with three narrow confluent yellow stripes, the laterals abbreviated anteriorly; pleura fuscous. Legs yellow; hind coxæ slightly dusky; mesothoracic coxal spurs longer than their coxæ and tapering distally to the two black teeth; the fore basitarsi longer than their tibiæ. Abdomen with six visible abdominal segments; fuscous; with the narrow posterior margins of the segments yellow; venter yellow basally, distad fuscous. Hypopygium subfuscous (figures 12 and 17).

Type collected at Beaver Lake near Jasper, Alberta, August 15, 1934. Paratypes from Beaver Lake and a defective paratype from Katahdin, Maine, August, 1913 (3,000 feet), collected by C. P. Alexander. Type (No. 1414) in the Cornell University Collection.

Mycomyia alternata new species.

MALE. Length 3 mm. Head black; palpi, proboscis, and flagellum black; scape yellow. Thorax yellow; prothorax with three prominent setæ; mesonotum without stripes; scutellum with four prominent setæ; postnotum subfuscous caudad; pleura yellow, except the subfuscous pleurotergite. Legs yellow; mesothoracic coxæ lack spurs; fore tibiæ longer than the fore basitarsi. Wings hyaline; Sc ends in R_1 at about the middle of cell R_1; C ends at R_{4+5} before the tip of the wing; cell R_1 about three times as long as wide; M_3 longer than the petiole of M; Cu forks distad of the r-m cross-vein. Halteres yellow. Abdomen yellow; posterior margins of the tergites brown. Hypopygium as in figure 5.

Type from McLean Reservation, McLean, New York. August. Type (No. 1413) in the Cornell University Collection.

Mycomyia dentata new species.

MALE. Length 3.5 mm. Head fuscous; mouth parts, palpi, scape, and base of first flagellar joint yellow. Thorax brown; prothorax with three strong setæ; mesonotum with indications of three dark stripes; scutellum with four strong setae. Legs yellow. Halteres yellow. Wings hyaline; Sc ends in R_1 before the middle of cell R_1; cell R_2 twice as long as wide; Sc_2 absent; C ends at R_{4+5} before the wing tip; petiole of M longer than M_3; Cu forks distad of the r-m cross-vein. Hypopygium as in figure 10.

Type from Shelburne, N. H., collected by C. P. Alexander. Type (No. 1416) in the Cornell University Collection.

Mycomyia intermedia new species.

MALE. Length 4 mm. Head black; palpi, proboscis, and antennæ black except the basal part of the first flagellar joint which is yellow. Thorax black; the three stripes of the mesonotum separated by shining areas; humeri lighter; pleura black; prothorax black with about five prominent setæ. Coxæ dusky; spurs of the mesothoracic coxæ little longer than the trochanters, their bases dark, yellow distad, ending in two black teeth; fore tibiæ longer than the fore basitarsi. Wings hyaline with a small black spot at the base of Cu; C ends at R_{4+5} at the wing tip; Sc ends in C over the proximal end of cell R_1; Sc_2 over the proximal end of cell R_1; cell R_1 about twice as long as wide; petiole of M shorter than M_3; Cu forks just proximad of the r-m cross-vein. Halteres yellow. Abdomen black. Hypopygium as in figure 23.

Type from Fair Oakes, Calif., May 10, 1918. Type (No. 1412) in the Cornell University Collection.

This species is apparently close to *Mycomyia fuscibasis* Van Duzee, but differs in leg proportions and in the hypopygial structure. The antennal bases have less yellow. Sc ends proximad of the middle of cell R_1. In Johannsen's key it runs down to *M. calcarata,* but is separable from that species by having the petiole of M less than half as long as M_1; the spurs of the middle coxæ are less than half the length of the coxæ; cell R_1 more than 1.5 times as long as broad; and the mesonotal stripe is not distinctly divided.

The differences between the new eastern species and other species are shown in the key.

Docosia paradichroa new species.

MALE. Length 4.5 mm. Head and antennæ black; palpi subfuscous, lighter distad. Thorax wholly black, shining. Legs yellow, tarsi are infuscated distally; fore basitarsi shorter than their tibiæ. Halteres yellow. Wings hyaline; Sc ends in R_1; r-m cross-vein longer than the stem of M; fork of Cu proximad of the fork of M and proximad of the tip of Sc. Abdomen mainly yellow; sixth segment with diffuse black spot on both tergite and sternite; eight and ninth segments wholly black. Hypopygium (figure 6) black.

Type and three paratype males taken at the Wild Flower Preserve, Slaterville, New York, May, 1935. Feeding on slime flux of maple. Type (No. 1417) in the Cornell University Collection; paratypes in my collection. This species resembles *Docosia dichroa* Loew but differs in the structure of the hypopygium, in lacking the group of numerous black spines on the inner tip of the hind tibia and in possessing two short, black, peg-like spines anterior to the hind tibial spurs.

Exechia clepsydra new species.

MALE. Total length 4.5 mm. Head deep fuscous; palpi, scape, and first flagellar joint yellow. Thorax chiefly fuscous; prothorax yellow with five setæ on each side; mesonotum deep fuscous; pleurotergites with six prominent setæ; scutellum with two small setæ, followed posteriorly by two large setæ; hypopleurite yellow. Legs yellow; fore basitarsi longer than their tibiæ; base of middle and hind femora with an oval brown spot beneath. Wings hyaline; Sc short ending in R_1; curvature of R_s not conspicous. Halteres yellow. Abdominal tergites mainly fuscous; first tergite with a minute basal yellow triangle; tergite three with lateral yellow spots which cut laterally into the dorsal

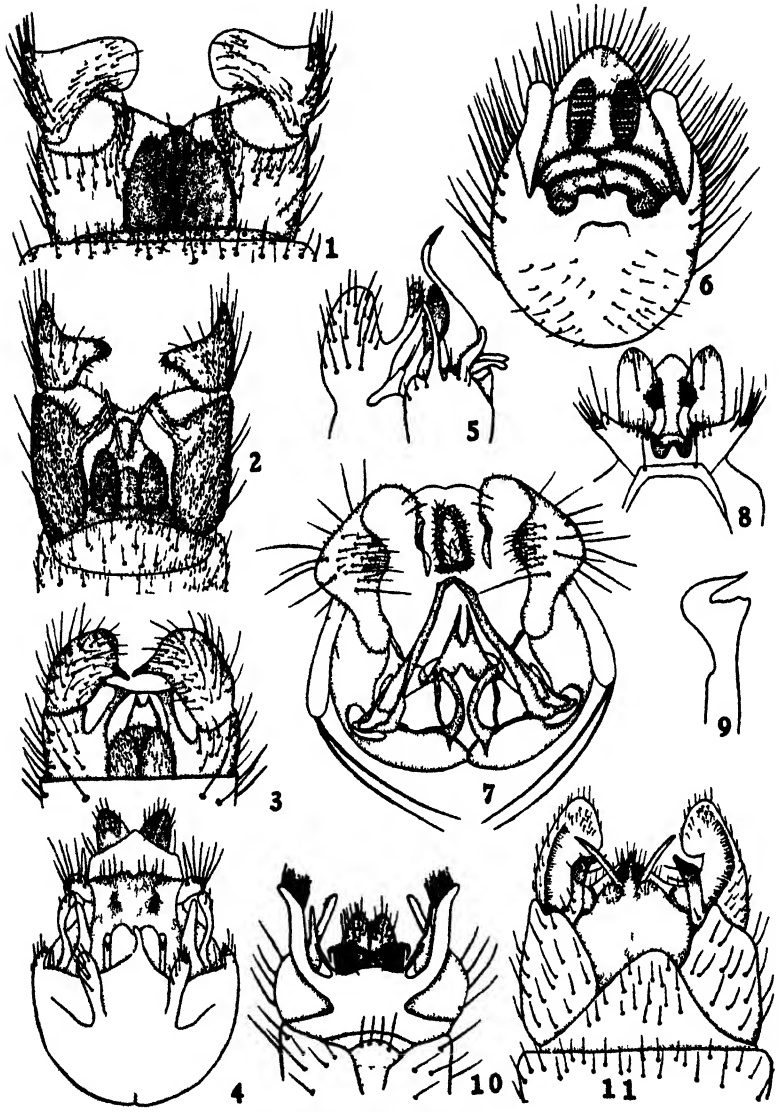
brown making almost an hour-glass shaped mark (hence the specific name). Hypopygium (figure 18) yellow.

Type from Fillmore Glen, New York, Nov. 18, 1934. Type (No. 1419) in the Cornell University Collection. In Johannsen's key this runs down near *E. capillata* and *E. absoluta* but differs greatly in the form of the hypopygium as well as in the color and in leg proportions.

PLATE 29

1. *Bolitophila distus* dorsal* aspect of hypopygium.
2. *Bolitophila alberta* dorsal aspect of hypopygium.
3. *Bolitophila acuta* dorsal aspect of hypopygium.
4. *Mycomyia turitella* ventral aspect of hypopygium.
5. *Mycomyia alternata* lateral aspect of hypopygium.
6. *Docosia paradichroa* ventral aspect of hypopygium.
7. *Mycomyia dichæta* caudal aspect of hypopygium.
8. *Mycomyia turitella* dorsal aspect of hypopygium.
9. *Mycomyia dichæta* lateral aspect of forceps (styli).
10. *Mycomyia dentata* dorsal aspect of hypopygium.
11. *Platyura pellita* ventral aspect of hypopygium.

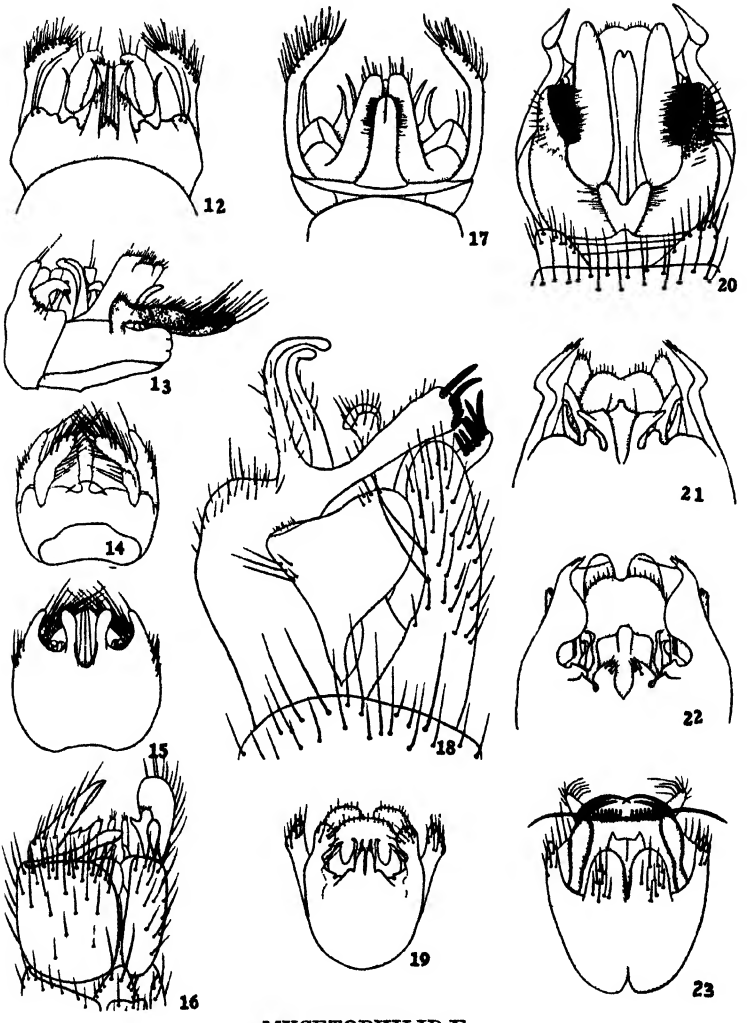
* Refers to the morphological dorsal, ventral, and lateral aspects and not to the actual aspects which may vary in different individuals.



MYCETOPHILIDÆ

PLATE 30

12. *Mycomyia curvata* ventral aspect of hypopygium.
13. *Mycomyia hirticollis* lateral aspect of hypopygium.
14. *Mycomyia hirticollis* dorsal aspect of hypopygium.
15. *Mycomyia hirticollis* ventral aspect of hypopygium.
16. *Exechia clepsydra* latero-ventral aspect of hypopygium.
17. *Mycomyia curvata* dorsal aspect of hypopygium.
18. *Neoempheria digitalis* lateral aspect of hypopygium.
19. *Mycomyia pseudomaxima* ventral aspect of hypopygium.
20. *Mycomyia scopula* dorsal aspect of hypopygium.
21. *Mycomyia scopula* ventral aspect of hypopygium.
22. *Mycomyia parascopula* ventral aspect of hypopygium.
23. *Mycomyia intermedia* ventral aspect of hypopygium.



MYCETOPHILIDÆ

NOTE ON GIANT SWALLOW-TAIL BUTTERFLY IN NEW JERSEY

Papilio cresphontes Cr., the largest of our swallow-tails, is of rather wide distribution but apparently somewhat local. In the South the larva is known as the "Orange Dog"; in the more northern states its food plants are Prickly Ash (*Zanthoxylum americanum* Mill.), Hop Tree (*Ptelea trifoliata* L.) and occasionally American Bladdernut (*Staphylea trifolia* L.), where these occur. In southern New Jersey the species is rarely seen, but last August one female was noticed for about a week in Moorestown, Burlington County, where she oviposited on an isolated Bladdernut shrub on the property of Edward Haines. The larvæ developed in due course and scattered for pupation.

In the hills of northern New Jersey, however, the giant swallowtail is not uncommon. Here are considerable patches and borders of Prickly Ash and Bladdernut. During the past season (1937) larvæ of various sizes were, it seemed to me, unusually plentiful on Prickly Ash throughout the summer and autumn. The larvæ, with an odd pattern of olive and white, strongly resemble bird-droppings. The pupæ, similarly colored, seem to be constant in this character instead of varying to brown or green as in *polyxines* and *troilus*.

The locality of greatest abundance for *cresphontes* appears to be the limestone foothills of the Jenny Jump Mountains in Warren County.—R. J. S.

THE VERMIN KILLER: 1775 MODEL

BY HARRY B. WEISS

In 1775 there was printed in London for S. Bladon of Lombard Street, a little book ($5\frac{1}{4} \times 3$ inches) of 52 pages entitled: "The Vermin-Killer: Being A very necessary Family-Book, Containing Exact Rules and Directions for the artificial killing and destroying all Manner of Vermin, *viz.* Bugs, Rats and Mice, Fleas and Lice, Moles, Pismires, Flies, Catterpillars, Snakes, Weasles, Frogs, etc. Whereunto is added, The Art of taking all Kinds of Fish and Fowl, with many other Things never before known."

The author of this treatise, one W. W., wrote in the preface that he had brought his material together because, many times, mankind is more disturbed by small and inconsiderable insects than by the more noble species of sensitive creatures. Furthermore the "infallible remedies" laid down by him were deduced not only from the writings of learned and judicious authors, but also from the constant experiences of various persons who had tried the remedies and had benefited therefrom.

The remedies in this little book are typical of the brand of economic entomology that flourished before anyone thought of bringing "economic" and "entomology" together, and at a time when the entomologists themselves were not concerned with such a "low" phase of their subject.

Because of their quaintness some of these remedies are reproduced herewith just as they appear in "The Vermin-Killer."

To kill Bugs

Take a convenient quantity of fresh tar, mix it with the juice of wild cucumber, let it stand a day or two, stirring it four or five times in a day, then annoint the bedsteads with it, and all the bugs will die.

Another

Take the gall of an ox, and mix it with vinegar, and rub the cracks and joints of the bedstead with it, and all the bugs will die in a short time.

Another

Take a quantity of brimstone, beat it to powder, then mix the powder with old oil, and use it as before.

Another

Take strong glue, and boil it with vinegar, and rub the bedsteads with it, and the bugs will certainly die.

Another

Take quick-silver and mix it with hog's grease, of each a like quantity, use it as before.

To kill Pismires

Take the roots of wild cucumbers, and set them on fire where the pismires are, and the smoke will kill them.

To drive away Pismires

Take an earthen dish, full of pismires and the earth where they are, and make a good fire, and put the earthen pot on the fire, and the pismires will not remain near that place.

Another

Take mussel shells, burn them with storax, and beat them to a small powder, and straw the powder where the pismires usually are, as the great banks, and they will all come out of their holes, and kill them.

To keep the Sugar box or Spice from the Pismires

Cover your sugar box with white wool, or annoint it with rubica.

To kill Fleas

Take wormwood, and the root of wild cucumber, and boil them in pickle, and sprinkle it in the room, and it will certainly kill the fleas.

Another

Take soap lees, and boil two or three onions in it, let it cool, then sprinkle the room with it, and it kills the fleas.

Another

Take lee and she-goat's milk, and it is an infallible remedy.

To gather all the Fleas together that are in the Room

Take an earthen pot, and cut a hole in the floor of the room, so big as the pot may stand with the mouth even with the floor of the room, then take the blood of an ox, and mix it with the soot of a chimney, and rub it in the inside of the pot, and all the fleas will come into the pot in a day's time.

Another

Take a small piece of wood, as big as a man's arm, and rub it over with hog's grease, and all the fleas will gather to it, if you lay it in the middle of a room.

Another

Take the blood of a bear or badger, and put it under the bed as before, and it gathers the fleas to it, and they die immediately.

To kill Lice

Take salt water and rub the afflicted places with it, or vinegar, or onion, and mix in it allum and alloes, and therewith annoint the place.

Another

Take hog's lard, quicksilver, and sage, as much of each as is needful, mix them together to a salve, and annoint the afflicted places.

To kill crab Lice

Take a roasted apple, and take the skin and core from it, and beat it in a mortar with as much quicksilver as will make it into an ointment, and therewith dress the afflicted places.

To kill Caterpillars

Take fig leaves ashes, and cast it on the root, and it destroys caterpillars.

Another

Take a gallon of crabs, and steep them ten days in water, and sprinkle the trees with the water, and it kills the caterpillar.

Another

Take a quart of the morning-dew, and mix in it verdegrease, or for want of that, take such a quantity of the juice of four

crabs, and mix a little verdegrease in it, sprinkle the root, branch, or place so infected and it certainly kills them.

To kill Flies

Take white hellebore, and steep it in sweet milk, mix with it orpiment, and sprinkle the room, and places where the flies come, and they will all die.

To gather the Flies together

Take a deep earthen pot, and lay in it beaten coliander, and all the flies in the house shall be gathered together.

To keep Cattle from injury by Flies

Annoint the beast with oil, wherein bakeler hath been boiled, and the flies shall not come near him.

The compounds advocated for insect control in "The Vermin Killer," include tar, vinegar, ox gall, ox blood, sulphur, glue, oil, hog's grease, wax, quicksilver, soap dregs, lime, goat's milk, salt water, alum, olive oil, ashes of fig leaves, saltpetre, sheep's dung, verdegris, mussel shells, red orpiment and botanical remedies involving the use of wild cucumbers, ivy, wormwood, rue, white hellebore, Marjoram, Lupine, Daphne, mustard seed, aloes, lavender, Amaranthus, Scilla, Scolopendrium, etc.

At first glance these may seem to be more antiquated than they really are. As a matter of fact, the forerunner of the economic entomologist had at his disposal, oil, glue, sulphur, mercury, arsenic, soap lime, etc., even though he did not use them as knowingly or as intelligently as they are being used today.

The non-entomological remedies in "The Vermin Killer" are of the same type as the entomological ones. "To gather together all the Rats and Mice into one Place in a House or Barn, and to kill them," one was supposed to "Take two or three living rats or mice, and put them into an earthen pot, then stop the pot close, that the rats or mice cannot come forth, then make a fire of ashen-tree wood, and place the pot on the fire, when it burneth moderately, and all the rats and mice in the house, hearing the cry of those in the pot, will run immediately to the place where the pot standeth on the fire, as if they did intend by force to deliver the rats and mice in the pot."

I have not attempted to identify W. W. who wrote "The Vermin Killer." It would be interesting to know if he made other economic contributions to entomology and also something of his entomological life but—an ocean, and the 162 years between me and his uncertain literary remains are obstacles which I have no ambition to overcome at this time.

NEW JERSEY LACE BUG NOTES

In Circular No. 54, N. J. Dept. Agric. (1922), "The Lace Bugs of New Jersey," by Weiss and Barber, the Elm Lace Bug (*Corythuca ulmi* O. & D.) is mentioned as of probable occurrence in this state, but no record is given. In the Weiss collection of *Tingitidæ* I find several specimens of *ulmi* marked "Beatyestown, N. J. IX–20"—no year indicated. Doubtless these were collected after the publication of the paper of 1922.

On August 13, 1937, a small infestation of *ulmi* was discovered on young elms along the river road near Lambertville, N. J. Thirty specimens were collected.

In 1936, near Byram, a few miles up the Delaware from Lambertville, a good colony of the large and beautiful *Corythuca bulbosa* O. & D. was discovered on its food-plant, American Bladdernut. This species was found several years ago by Weiss near Monmouth Junction, but had not been reported as occurring elsewhere in New Jersey.

In the fall of 1936 a few specimens of the Fringe Tree Lace Bug [*Leptoypha mutica* (Say)] were found on native *Chionanthus* along the Maurice River near Vineland. A number of years ago the species was seen in numbers by Mr. Weiss in a nursery in Hammonton, N. J., but was not located on native trees.—R. J. S.

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF FEBRUARY 2, 1937

A regular meeting of the Society was held on February 2, 1937; President Curran in the chair with twenty-three members and thirty-five visitors present.

The program committee reported that the next session would be given over to a general discussion of "Methods of Rearing Insects," led by Miss Lucy W. Clausen.

The following were proposed for active membership: Mr. Norman L. Rumpp, 244 W. 104th Street, New York City; Mr. W. N. Boyd, Millerick Ave., Trenton, New Jersey, R. D. No. 4, and Miss Dora Harris, 16 South Broad Street, Elizabeth, New Jersey.

Dr. A. L. Melander called attention to the death of Professor Brunner, an Orthopterist of California.

Dr. Horsfall made a motion, seconded by Dr. Moore, that the chair appoint a committee to take under consideration and report within two months, to the executive committee for action, the desirability of forming a junior membership class.

The President announced that he would name the committee at the next meeting of the Society.

Dr. C. C. Hamilton, the speaker of the evening, was then introduced. Mr. Hamilton's topic was the "Use of the Airplane and Autogyro in Insect Control." Some problems that have already been treated successfully are—the control of cotton insects in the South, tomato worms in California, blunt-nosed leafhopper in cranberries in N. J., leafhoppers on beets in the West, grasshopper poison bait in the Middle West. The great problem to be faced is the prevention of drifting of the sprays. In this connection it has been found that a concentrated arsenical spray will not drift as much as a dust spray. By the addition of petroleum oil evaporation is prevented.

In striving to take up a greater pay-load most of the time is taken up in loading and in the preparation of equipment. The cost of dusting is therefore dependent upon the pay-load. An airplane goes along on an even keel and the dust gradually spreads and settles. The autogyro, however, flies at an angle and makes for better distribution.

A general discussion of Mr. Hamilton's paper closed the evenings meeting.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF FEBRUARY 16, 1937

A regular meeting of the Society was held on February 16, 1937; President Curran in the chair with twenty-eight members and twenty-three visitors present.

The following were elected to active membership: Miss Dora Harris, Messrs. Rumpp and Boyd. The by-laws were suspended in order to elect Dr. Nellie M. Payne to active membership.

Dr. Curran announced the committee on Junior Membership as follows: Mr. M. Kisliuk, Mr. A. J. Mutchler, Mr. Bird, Dr. Ruckes, Dr. Horsfall.

A discussion, by members, on "Methods of Rearing Insects," occupied the rest of the meeting.

LUCY W. CLAUSEN, *Secretary.*

MEETING OF MARCH 2, 1937

A regular meeting of the Society was held on March 2, 1937; President Curran in the chair with twenty-seven members and twenty-one visitors present.

Dr. Klots spoke on "Lepidoptero-geography in the Rocky Mountains." A series of lantern slides illustrating the chief environments and Life Zones, as well as details of some plant successions, was shown.

LUCY W. CLAUSEN, *Secretary.*

An abstract of the remarks by Dr. Klots follows.

The following mountain ranges were investigated in 1936:

HALL VALLEY, COLORADO

Worked thoroughly from 13,000 ft. down to 9200. *Brenthis frigga sagata* Barnes & Benjamin was found at 9200 ft. in a senescent, acid bog that was growing up to heath. *Brenthis aphirabe alticola* Barnes & McDunnough was found in grass and sphagnum bogs from 9500 ft. to 11,000 ft. A new species of *Crambus* was taken in Hudsonian Zone at about 11,200′; this species has also been taken by the author on Pike's Peak and in the Snowy Range, Wyo., and by Dr. Brower in nearly identical environment on Mt. Katahdin, Maine—a striking example of Life Zone distribution.

SANGRE DE CRISTO RANGE, NEW MEXICO

Collecting in lower and middle Canadian Zone. A good series of a new race of *Colias scudderi* was taken in grassy, Iris-Rudbeckia meadows.

SAN FRANCISCO MTS., ARIZONA

The range was badly desiccated, and collecting was very poor. A range surrounded by desert must have a considerable area of forest around the high peaks, or else the hot, drying desert winds will prevent the formation of any great area of tundra above timberline. This is constantly happening here; in addition the whole interior of the range has been badly burned, and there has been much overgrazing.

TUSHAR RANGE, UTAH

Bad weather, with heavy rains and hailstorms, prevented much collecting above timberline. There is a considerable area of true Arctic-Alpine Zone,

and interesting forms should occur here; for this is the most southern of the Utah ranges to possess any considerable area of true tundra.

UINTAH MTS., UTAH

Considerable collecting was done on the mountains surrounding the Mirror Lake Basin. On Mt. Murdock, *Erebia magdalena* Strecker was found in abundance, over 40 specimens being taken in one morning. This species and *Lycaena snowi* Edwards are definitely very petrophilous, flying by choice over barren rockslides on steep slopes. On a lower shoulder of Hayden Peak, an *Oeneis* of the *brucei-semidea* group was taken. This group of *Oeneis* is found only in extreme Arctic-Alpine tundra environment, and serves as an indicator for this zone. The other group of the genus, comprising such species as *chryxus* and *jutta* are found at lower elevations, often down to the middle Canadian Zone.

LA SAL MTS., UTAH

Very few of the typical high altitude butterflies were taken in this range, but such as occurred (*Lycaena snowi, Brenthis helena* and *Parnassus smintheus*) show that the relationship of this part of the fauna is definitely with the Colorado mountains which lie to the East of the range, rather than with the Utah mountains to the North and West. The range is surrounded by hot, dry desert, which must effectively bar any present-day exchange of high altitude butterflies with other ranges.

SAN JUAN MTS., COLORADO

In the course of collecting at high altitudes in this range, such famous peaks as the Wetterhorn and Uncompaghre were climbed by some of the party, and interesting faunal and floral observations were made. *Oeneis uhleri* was taken in Upper Canadian Zone, on a lush mountainside; this is one of the "low altitude group" of the genus. A large series of an undescribed species of *Crambus* was taken at camp, which was located at the formerly flourishing, now nearly deserted, mining camp of Capitol City. *Erebia callias* was taken at the base of the final slope of the Wetterhorn; but *Erebia demmia* Warren, recently described from material taken in the San Juans on a former trip by Mr. Whitmer, of our party, and Mr. Davenport, was not found.

MEETING OF MARCH 16, 1937

A regular meeting of the Society was held on March 16, 1937; President Curran in the chair with twenty-eight members and seventeen visitors present.

The speaker of the evening, Dr. Argo, then told about beehives and apiaries. Dr. Argo said that a study of bees is a study of insect psychology. They have a long list of instinctive responses which bear only upon the preservation of the species and not the individual. Slides were shown illustrating the various steps in queen breeding. At the close of Dr. Argo's talk members participated in a general discussion.

LUCY W. CLAUSEN, *Secretary.*

NOTES ON DIPTEROUS PARASITES OF SPIDERS

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In the course of some studies carried on at the Osborn Zoological Laboratory, Yale University, I had the opportunity to note a few cases of parasitism of spiders by insects. By far the greater proportion of these parasites are Hymenoptera; a few are Diptera. Diptera bred from egg cocoons have been reported by Coquillet (1892, 1898), Davidson (1894), C. Koch (according to König, 1894), Brues (1902, 1903), Auten (1925), Kintner (1935), and Herms *et al.* (1935). Internal parasites of spiders themselves have been Diptera of the family Cyrtidæ.[1] The members of this family are admittedly uncommon in entomological collections, and naturally specimens are more apt to be reared by collectors of spiders than of Diptera. The first specimen reared was an *Ogcodes pallipes* Erichson from *Clubiona putris* Koch by Menge (1866). Brauer (1869) reared *Astomella lindenii* Er. from *Cteniza ariana* Koch. Emerton (1890) obtained a specimen that proved to be *Acrocera fasciata* Wiedemann from *Amaurobius bennetti* Blackwall. The same species was reared by Montgomery (1903) from *Schizocosa crassipes* (Walckenaer). *Ogcodes doddi* Wandolleck was bred from *Cosmophasis bitaeniata* Keyserling (Wandolleck, 1906). King (1916) gave a very complete account of the life history, and description of all the stages of *Pterodontia flavipes* Gray. The hosts are *Araneus sericatus* Clerck and *Lycosa pratensis* Emerton. Nielsen (1932) reared *Acrocera globulus* Panzer from a *Lycosa* sp., and *Ogcodes gibbosus* Linn. from *Prosthesima* sp.

Johnson (1903) in discussing Montgomery's rearings suggested that "many spiders, perhaps 25 per cent., are thus parasitized." However, it is my opinion that Montgomery's case was unusual. Even spiders bearing hymenopterous larvæ, which are ectopara-

[1] McCook (1890) refers to a *hymenopterous* larva emerging from the body of a spider, but this is probably an error. The specimen was not reared.

sitic and hence easily seen, are seldom encountered in nature. This was pointed out by the distinguished Danish araneologist, Nielsen, who has investigated the life histories of many hymenopterous parasites, yet has reared but two cyrtids. Of the close to a thousand spiders I have kept alive in the laboratory for considerable periods of time during the last four years I found only five so parasitized.

According to Johnson (1915), Montgomery was able to detect those spiders which were parasitized long before the emergence from the host. On the contrary, the spiders I had gave no indications of being parasitized even up to within a day or so of the parasites' emergence, though they were being closely observed almost daily in various experiments. Hence the parasite must grow at a tremendous rate during the last few hours of the host's life.

I am indebted to Dr. C. H. Curran of the American Museum of Natural History for his kindness in determining the flies, and to my wife for the illustrations.

Ogcodes costatus Loew.

The host spider was an immature *Lycosa* sp. collected at Orange, Conn., May 9, 1935. It was killed May 22 by the emergence of the parasite larva which had cut its way out through the ventral side of the abdomen near the anterior end (Fig. 1). The cephalothorax and coxæ were eaten out as well as the abdomen, but only the latter was shrivelled. The fully developed larva (Fig. 2) is markedly different in appearance from the corresponding stages figured by Brauer for *Astomella,* by Emerton for *Acrocera,* by King for *Pterodontia,* and by Nielsen for *Acrocera.* It agrees somewhat with the brief descriptions of *Ogcodes pallipes,* and of *O. gibbosus* as given by Menge and Nielsen, respectively. The young stages of cyrtid larvæ have been described by Maskell (1888), König, and King. They differ both in structure and method of movement from the fully developed stages.

The larva was 9.35 mm. long and had a glistening sticky skin which caused particles of debris to adhere to it. There was a small inconspicuous head, light yellow in color. Of the mouth-

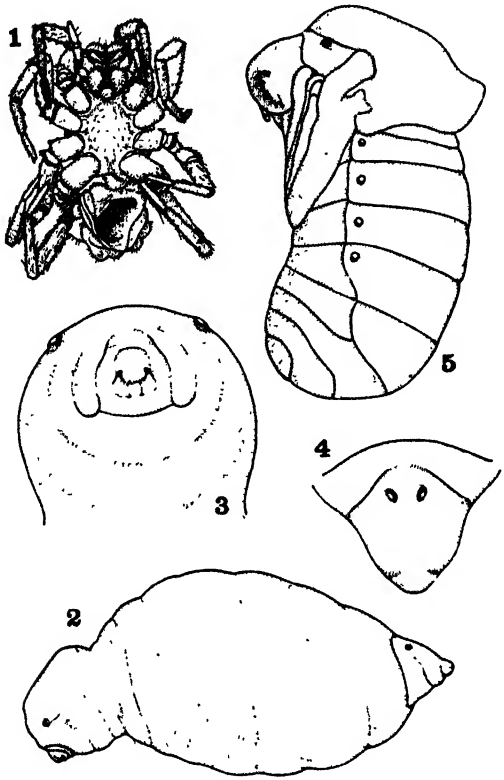

Figure 1. Ventral aspect of *Lycosa* sp. killed by the emergence of *Ogcodes costatus* larva.
Figure 2. Left lateral aspect of *O. costatus* larva after emergence from host.
Figure 3. Ventral aspect of anterior end of larva.
Figure 4. Dorsal aspect of posterior end of larva.
Figure 5. Left lateral aspect of pupa.

parts (Fig. 3) only a pair of darkly pigmented mandibular or oral hooks could be discerned. There was a distinct globular yellowish thorax. Faint indications of its subdivisions were present on the ventral side, and a pair of darkly pigmented spiracles were borne near the dorsal surface of the prothorax. The tracheæ connecting with these were visible for some distance beneath the skin. The abdomen was large, creamy white, and divided into what

appeared to be seven indistinct precaudal segments and a distinct conical upwardly sloping caudal segment. The latter was itself partly divided by two ventral folds, and bore a pair of spiracles on its dorsal surface (Fig. 4).

On May 23 it pupated. The excrements voided before pupation remained as a long, thin, black, curved string extending from the caudal end of the pupa. Malloch (1915) described the pupa of this species and figured the abdomen. Unfortunately his material was very poorly preserved so that the description is not entirely applicable here. The total length was about 6.25 mm., measured from the disc of the prothorax, as the head was bent down considerably on the ventral side of the thorax (Fig. 5). On either side of the head were two sextets of papilliform processes which were pigmented at the tips. In this and in having the posterior three segments (6 to 8) of the abdomen slightly telescoped into the preceding, it resembled *Pterodontia* as described and figured by King. Malloch described the head as being "without discoverable protuberances or hairs," and figured the last segment of the abdomen protuberant. There were a pair of prothoracic spiracles, and a pair on each of the first four abdominal segments, all elevated from the general body surface.

On May 28 the pupa had become quite dark and looked ready to emerge within a day or so. There was very little change in appearance on the succeeding days and on June 1 it was dead. The probable duration of the pupal period is 6 to 7 days.

Ogcodes pallidipennis Loew.

According to Cole (1919) an individual of this species in the U. S. National Museum collected by A. A. Girault at Coulterville, Ill., has a label "Bred from cell of *Sceliphron cementarius.*" Iss. June 18, 1919." This mud-daubing wasp provisions its nest with very many species of spiders so that the particular host of the parasite cannot be ascertained. In the collection of the Connecticut Agricultural Experiment Station there are two specimens. One label reads "New Haven, Ct., 13 July 1904, P. L. Butrick"; the other, "Pine Orchard [in Branford] Ct., 26 July 1904, H. L. Vierick."

My observations on this species were unfortunately not as detailed as for *O. costatus,* due to press of other matters, nor were any drawings made. However, I can recall that the larva closely resembles that of *costatus.* I have no recollections concerning the pupa. In all four cases which I observed, the parasite left the host through the latter's abdomen, after cleaning out the cephalothorax and coxæ as described for *costatus.*

From an immature *Pardosa banksi* Chamberlin collected at Indian Neck in Branford, Conn., May 17, 1932, the parasite emerged July 1. It was not reared. From a similar specimen collected with the first, the parasite emerged July 16, pupated July 17, and the imago emerged July 22. From a mature female of the same species collected in the same locality June 7, 1933, the parasite emerged July 7, pupated July 8, and the imago emerged July 14. From an immature *Pardosa saxatilis* (Hentz) collected at New Haven, Conn., May 18, 1934, the parasite emerged June 14, pupated June 15, and the imago emerged June 20. This indicates the duration of the pupal period to be 5 to 6 days. All the imagines were very sluggish, not flying at all, and walking about only when poked.

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Note. Some time after this manuscript left my hands for the editors I happened upon a note by A. Giard (1894, Sur quelques parasites des araignées, Bull. Soc. Ent. France, pp. CLIII–CLV). This author collected a specimen of *Ogcodes pallipes* standing near the pupal skin from which it had recently emerged. Nearby were the remains of a *Clubiona* sp., its host. Mr. K. C. McKeown of the Australian Museum has recently written me that "there are records of unnamed Cyrtidæ attacking several species of spiders" in Australia.

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